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Attachment 1
Revised Pages of Draft FS in Strikethrough/Underline Format

(Note: To ensure completeness, all proposed changes to the draft FS (i.e., those discussed in both the 29 June and 14 July submittals) are being provided)

revised and resubmitted separately the RI, BLRA, and FS in that order for USEPA review and approval before proceeding to the next submittal. The final RI and BLRA have been approved (December 1998 and June 1999, respectively), and this FS reflects the findings from an evaluation of remedial alternatives for OU2 based on the approved RI and BLRA.

Coincident with the latter stages of the RI/FS, in August 1995, USEPA issued an *Order on Remedial Action* to Mr. Thompson and Sequa to implement the OU1 ground water recovery, treatment and water supply system, as well as related components of the OU1 remedy. In correspondence dated November 17, 1995 Sequa notified USEPA of its intentions to comply with the Remedial Action Order. Construction of the OU1 treatment system and related components by Sequa occurred over the 1996/1997 timeframe and the system became fully operational in the summer of 1998.

As with all Superfund sites, the two paramount remedial action objectives for the Dublin NPL Site FS are: 1) protection of human health and the environment, and 2) compliance with all ARARs. These objectives constitute the threshold criteria in the selection of a final site remedy - that is they must be achieved by a final remedy in order for the remedy to be an acceptable final remedy in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Additional remedial action objectives, which relate to USEPA's "expectations" for Superfund sites with ground water contamination, were also established and factored into the screening of remedial technologies and evaluation of alternatives. These additional objectives for consideration were: source control; prevention of plume migration; and restoration of ground water to beneficial uses.

Two features of the Dublin site ~~make this FS unique~~ were integral to the development of this FS. The first relates to the fact that, in terms of risk, this FS only addresses predicted future conditions. The second relates to the remaining presence of TCE deep in the fractured bedrock at the site and the lack of available technology to completely remediate the TCE.

Since the successful implementation of the OU1 remedy eliminated risks to human health and the environment under current conditions (ref. USEPA, 2000), the uncertainties that need to be addressed by the OU2 remedy with regard to protection of human health and the environment primarily relate solely to future conditions. Modeling is a conventional means of predicting general trends for potential future conditions, especially as they relate to ground water flow and contaminant transport.

Modeling, however is not an exact science. Therefore, any reliance on modeling must consider its limitations. Nevertheless, despite its limitations, modeling remains a valuable tool for predicting future conditions[1]. A combination of a three dimensional ground water flow and solute (i.e., contaminant) transport model was used to predict potential future conditions under a number of potential remedial scenarios.

During the technology screening step of the FS process, a total of 27 remedial technologies and/or process options were screened for applicability to the Dublin Site. All technologies were screened for applicability to the Dublin Site based on effectiveness (in achieving the stated remedial action objectives), implementability, and relative cost.

Eleven technologies were retained as being applicable and were subsequently assembled into complete remedial alternatives.[2] Since it was determined in the BLRA that ground water was the only media of concern (i.e., the only media that posed unacceptable risks to human health and the environment), the majority of the technologies that were identified and screened applied to the general response actions of containment, recovery, and treatment (in-situ and ex-situ) of either contaminated ground water or "source material" (i.e., source of contaminated ground water, which is suspected to be non-aqueous phase liquid (NAPL) in the immediate vicinity of the 120 Mill Street property).

Nine remedial alternatives were assembled and subjected to a detailed evaluation in accordance with the procedures presented in the NCP and

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[1] Because this FS relies almost solely on modeling, the selection of a final remedy should also consider a number of other means of analysis. These methods of analysis were completed in the RI to evaluate future temporal trends.

[2] ~~Note that the most aggressive alternatives were not developed in accordance with USEPA guidance (ref. USEPA, 1988), but rather were added to the detailed evaluation of alternatives at the direction of USEPA. Accordingly, these alternatives consist of component technologies or process options that may not have survived the technology screening process of a conventional FS. At the least, when subjected to a detailed evaluation, significant issues are raised relative to several of the technology screening criteria (e.g., "implementability" and "cost"). Nevertheless, the level of detailed evaluation performed is sufficient for conducting a comparative analysis of these alternatives relative to other candidate alternatives. However, if these alternatives are considered beyond this FS, additional detailed analysis would be required to confirm their feasibility and implementability.~~

Contingency Plan (NCP, 40 CFR 300), thereby ensuring that the recommended remedy is the most appropriate final remedy for the Dublin NPL Site.[1]

1.2 *PROJECT OVERVIEW*

The Dublin NPL Site ("Site") is defined as the 120 Mill Street Property located in Dublin Borough, Bucks County, Pennsylvania, as well as all adjacent areas to which site-related contaminants have migrated (USEPA, 1995) (see Section 1.3 for extent of contamination). Investigative activities began at the Site in 1986 when the Bucks County Health Department (BCHD) initiated routine sampling of water supply wells in the Dublin area. Contamination, principally trichloroethene (TCE), was detected in 36 supply wells. In 1987, Mr. John Thompson, current owner of the 120 Mill Street property, entered into a Consent Order with the USEPA to provide and maintain treatment systems for all residential and commercial locations where TCE was found at levels in excess of the Maximum Contaminant Level (MCL, i.e., drinking water standard). The Thompson Consent Order also required Mr. Thompson to monitor the impacted supply wells at frequencies which varied from quarterly to semiannually, depending upon the concentration of TCE detected in the wells.

A search for potentially responsible parties (PRPs) conducted by USEPA in 1987 identified a number of prior and current owners of the 120 Mill Street property, including Mr. Thompson, Athlone Industries, Inc., and Kollsman Instrument Corporation (KIC). Sequa Corporation is the corporate successor of KIC.

In June 1990, Sequa entered into a Consent Order with the Pennsylvania Department of Environmental Resources (PADER, subsequently the

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[1]-~~Note that the most extreme alternatives were not developed in accordance with USEPA guidance (ref. USEPA, 1988), but rather were added to the detailed evaluation of alternatives at the direction of USEPA. Accordingly, these alternatives consist of component technologies or process options that may not have survived the technology screening process of a conventional FS. At the least, when subjected to a detailed evaluation, significant issues are raised relative to several of the technology screening criteria (e.g., "implementability" and "cost"). Nevertheless, the level of detailed evaluation performed is sufficient for evaluating the alternatives. If these alternatives are pursued, additional detailed analysis would be required to confirm their feasibility and implementability.~~

extent of the plume lies within the Borough boundary and has been relatively unchanged since 1988.[3]

Several methods of data evaluation, including graphical presentations and statistical analyses, were presented in the RI (Geraghty & Miller, revised 1998) and associated supplement (ERM, 1998) to assess temporal trends in the TCE plume since 1986. The results for each of the various data evaluation methods are comparable, and support the general conclusion that the TCE plume in the bedrock aquifer is, at least, in a steady state condition. Appendix A contains time vs. concentration graphs and figures from the RI report that support this conclusion. More recent monitoring data collected during 1998 for residential supply wells located beyond the edge of the plume to the north and northwest also support this conclusion. The 1998 monitoring data continue to indicate that TCE concentrations beyond the boundary of Dublin Borough remain below the MCLs for drinking water.[4]

1.4 *BASELINE RISK ASSESSMENT FINDINGS*

As part of the RI/FS, a BLRA was conducted to evaluate and quantify risks to receptors potentially exposed to constituents of concern in the media impacted by historic operations at the Dublin NPL Site. The findings of the baseline risk assessment are presented in the final BLRA (ERM, June 1999).

In accordance with EPA Region III guidance, risk-based screening was performed to identify constituents of potential concern (COPCs) in soil, sediment and ground water that required further evaluation during the risk assessment. Potential receptors and exposure pathways were identified based on current and future land use and the impacted media identified by the RI findings. The receptor populations evaluated during the BLRA were current and future on-site commercial workers, future construction workers, and current and future off-site residents (adult and child). Exposure routes (i.e., ingestion, dermal contact and inhalation)

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[3] EPA's position is that the plume may not be in steady state because the vertical extent of the plume is not known and the pumping scenarios have changed with the completion of OU1 (USEPA, 1999).

[4] See Footnote 3.

implementation of the OU1 remedy. The municipal water supply and institutional controls are expected to prevent future use of impacted water within Dublin Borough for potable supply.

1.5 *FS APPROACH*

This FS has been conducted in accordance with the applicable provisions of the NCP and follows the general procedures for conducting Feasibility Studies presented in USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988).

In accordance with the applicable requirements and guidance, this FS consists of a multi-phase screening process to identify and select the most appropriate remedial alternative for the Site to protect human health and the environment. The major steps associated with the identification and evaluation of remedial alternatives in this FS are as follows (EPA, 1988):

- establishment of remedial goals (i.e., remedial action objectives) based on the findings presented in the final RI and BLRA;
- identification and screening of a focused group of potentially viable remedial technologies and process options for remediation of impacted media at the Site;
- development of preliminary remedial alternatives for the Site by assembling the most promising technologies and/or process options[5];
- detailed evaluation of the remedial alternatives against the nine evaluation criteria mandated in the NCP and EPA guidance; and
- a relative comparison of the potential remedial alternatives based on the results of the detailed evaluation.

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[5] ~~Note that the most aggressive alternatives were not developed in accordance with USEPA guidance (ref. USEPA, 1988) as described above, but rather were added to the detailed evaluation of alternatives at the direction of USEPA. Accordingly, these alternatives consist of component technologies or process options that may not have survived the technology screening process of a conventional FS. At the least, when subjected to a detailed evaluation, significant issues are raised relative to several of the technology screening criteria (e.g., "implementability" and "cost"). Nevertheless, the level of detailed evaluation performed is sufficient for evaluating the alternatives.~~

Discharge to Ground Water or Potable Supply Requirements

Discharges to ground water would need to conform with federal maximum contaminant levels (MCLs) for drinking water (40 CFR Part 141). TBCs for this action would be the federal secondary MCLs (40 CFR Part 143). Discharges to the Borough of Dublin municipal water supply system would need to be of sufficient quality that the municipal treatment system could reduce organic and inorganic constituents to MCLs and SMCLs.

Discharge to POTW or Surface Water Requirements (including the Municipal Storm Sewer)

Investigation of the sanitary sewer system and treatment capacity of the Borough of Dublin's publicly owned treatment works (POTW) indicated that up to a maximum of 14,000 gpd of additional flow can be accepted by the system[6]. The closest surface water discharge point would be Morris Run, a tributary of the East Branch of the Perkiomen Creek. This tributary has a classification for trout-stocked fisheries. The Dublin Borough municipal storm sewer represents another form of direct discharge (in addition to Morris Run) that could prove to be preferable to a direct discharge to Morris Run based on cost and property access issues (see Section 4.4)). At the likely point of discharge, Morris Run is believed to offer limited to no dilution capacity. The municipal storm sewer also offers no dilution capacity. Accordingly, applicable standards for surface discharge (either to Morris Run or the municipal storm sewer system) would be those contained in 25 Pa. Code Chapter 16 for toxic organics and metals, Chapter 93 for the majority of conventional parameters, and Chapter 95 for selected additional conventional parameters.

Off-site Disposal

Any off-site disposal of residuals that, based on analysis, would be classified as hazardous waste would need to comply with RCRA land disposal restrictions, including potential treatment requirements.

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[6] Note that expansion of the POTW to provide additional capacity is not retained as a viable option due to the combination of capital costs and routine use fees, which are considered excessive in comparison to other competing technologies/process options.

minimum, already reached a steady state condition (see Appendix A and Final RI Report - ERM, 1998)[7].

If additional measures are deemed necessary to achieve this RAO, or to resolve any uncertainties regarding plume dynamics, monitoring of sentinel wells may be an approach to accomplish this objective if the wells can be placed in locations that would allow sufficient time to implement additional remedial action to prevent further migration of the plume before adverse impacts occurred. Such an approach would provide a measure of protection for currently uncontaminated ground water and has been suggested by USEPA[2].

2.3.3 *Restoration of Ground Water to Beneficial Uses*

As previously discussed, restoration of ground water to beneficial uses is an expectation of USEPA "whenever practicable, within a timeframe that is reasonable given the particular circumstances of the site" (40 CFR 300). Since ground water in the vicinity of Dublin Borough is used for potable supply, restoration of the bedrock aquifer to allow potable use is deemed the optimal beneficial use. However, given the site-specific circumstances of the Dublin NPL Site, restoration of *all* contaminated ground water beneath and in the immediate vicinity of the 120 Mill Street property to potable water quality standards may ~~is~~ not be practicable. More specifically, the technical impracticability of restoring ground water to drinking water quality beneath and in the immediate vicinity of the 120 Mill Street property ~~in the vicinity of the Dublin NPL Site~~ is based on a combination of chemical (contaminant-related) and physical factors which characterize the Site. These factors, which are described in a general sense by USEPA (1993), are discussed below as they relate to the Site.

- Contaminant-related factors – Although not confirmed nor delineated by field verification, the presence of DNAPL is indicated by empirical data ~~DNAPL is likely present as indicated by empirical data~~ (i.e., TCE concentrations $\geq$ 1% of its solubility limit in water), regardless of whether it occurs as free-phase liquid or as a residual material in the

[7] See footnote 3 on page 6 ~~EPA's position is that the plume may not be in steady state because the vertical extent of the plume is not known and the pumping scenarios have changed with the completion of OU1 (USEPA, 1999).~~

Consequently, restoration of all impacted ground water to its most beneficial use, especially in the immediate vicinity of the 120 Mill Street property, ~~to its most beneficial use~~ may not ~~cannot~~ be achievable (based on predictions of the solute transport model) ~~achieved~~[8].

[8] As discussed in Section 4, the restoration that is predicted to occur in the more ~~extreme~~ aggressive pumping scenarios is only finite - i.e., it is contingent upon the continuous and indefinite pumping of a source control well; otherwise, high-strength contamination would migrate from the source area and recontaminate those portions of the aquifer where restoration is predicted to occur.

restoration of portions of the aquifer downgradient of the source area[9]. Source control technologies could prevent the continued migration of source strength material from the source area located both beneath, and in, the immediate vicinity of the 120 Mill Street property. Source control could minimize the potential for future adverse impacts to uncontaminated ground water and existing residential supply wells beyond the current extent of the TCE plume. Source control could also improve the potential for eventually restoring ground water quality in portions of the plume beyond the source where TCE concentrations exceed the MCL. Note, however, that total aquifer restoration does not appear to be achievable, as discussed in Section 4 and Appendix B.

Potentially applicable source control technologies consist of hydraulic barriers, interceptor systems, hydraulic controls, ground water collection/recovery, in-situ treatment and ex-situ treatment. Other technologies (e.g., institutional controls, monitoring, discharge/disposal of treated ground water or treatment system residuals) may also be appropriate to support a source control remedial strategy.

Contaminated Ground Water — General response actions to address contaminated ground water would apply to the remaining portion of the dissolved phase TCE plume beyond the immediate vicinity of the 120 Mill Street property. Empirical data collected since 1986 indicate that ground water in the bedrock beneath a portion of Dublin Borough exceeds the MCL for TCE. Data also indicate that the lateral extent of the TCE plume has remained relatively constant over time (~~see footnote 2, page 17~~see footnote 3, page 6). However, with changes in the hydraulic conditions of the bedrock aquifer as a result of the completed implementation of the OU1 remedy (i.e., operation of OU1 supply well and abandonment of private water supply wells), the potential exists for the areal extent and/or distribution of contaminant mass within the TCE plume to change in the future. (Note, however, that ground water modeling does not indicate any significant changes in the areal extent of the plume in the future - see Appendix B.)

The objective of technologies to address contaminated ground water beyond the source area is to prevent unacceptable risks in the future to

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[9] ~~It follows that where there are no risks and where aquifer restoration cannot be achieved, source control would be of no benefit. The absence of source control would be expected to result in a plume in steady state conditions, including a uniform concentration gradient.~~

Following review of the draft FS, USEPA directed Sequa to perform three additional solute transport simulations for three additional remedial pumping scenarios. For comparative purposes, in an attempt to determine whether any remedy would satisfy the RAO/expectation of aquifer restoration, each of the three additional simulations predicted the distribution of TCE over a 100-year time period (in contrast to the 30-year period modeled for the eight prior alternatives). A primary objective of the three additional simulations was to evaluate the feasibility of meeting the RAO/expectation of restoring the balance of the aquifer to drinking water quality (i.e., its beneficial use). The remedial scenarios include two primary components: complete source area containment, in conjunction with a pump-and-treat component for the downgradient dissolved phase plume. The pump-and-treat component was evaluated using a range of pumping scenarios that included adjustments in the pumping rate of the OU1 supply well and as many as 12 downgradient extraction wells.

The three additional remedial scenarios modeled were as follows:

- Alternative 4C - pumping a source area well at 20 gpm and the OU1 supply well at 40 gpm. The objective of this simulation was to depict the plume configuration over time when there is complete hydraulic containment of the source area and the OU1 well is pumping at the rate specified in the Record of Decision for OU1.

- Alternative 7 - pumping a source area well at 20 gpm, OU1 at 20 gpm, and three downgradient wells (EW-3, EW-5 and EW-10) each pumping at 5 gpm. The objective of this simulation was to depict the plume configuration over time when there is complete hydraulic containment of the source area, and extraction wells are situated to remove contaminant mass in areas between the source area and the OU1 well.

- Alternative 8 - pumping a source area well at 20 gpm, OU1 at 20 gpm, and 12 downgradient wells (EW-2 through EW-12) each pumping at 5 gpm. The objective of this simulation was to evaluate whether the timeframe for achieving aquifer restoration can be expedited with an ~~extreme~~ aggressive pumping scheme.

All ground water modeling focused on predicting the future migration of the TCE plume for each remedial pumping scenario being evaluated. The modeling reports (initial report dated September 1999 and subsequent report dated March 2000) and associated graphics are contained in Appendix B, and a summary of the modeling efforts is presented below.

isoconcentration contours are presented based on the predicted TCE concentrations generated by the solute transport model for select time intervals into the future. Graphs showing TCE concentrations over time for several observation points throughout the plume (see Figure 18 of Appendix B1) are also presented to evaluate temporal trends at specific locations impacted by the plume.

The results of the solute transport modeling were used to screen out several ground water pumping scenarios from further consideration and select pumping configurations for incorporation into the remedial alternatives developed for detailed evaluation (with the exception of Alternatives 4C, 7 and 8, which as noted previously were incorporated as remedial alternatives in the FS as directed by USEPA. The results for the four remedial pumping scenarios that simulated reduction of source concentrations as a result of in-situ treatment (i.e., 3B, 4B, 5B and 6) were very similar and did not show any reduction in the lateral extent of the plume. Consequently, with one exception (i.e., scenario 6 - OU1 supply well at 40 gpm with in-situ treatment of the source area), these scenarios were eliminated from further consideration. Scenario 6 was retained for further evaluation so that an alternative that included aggressive in-situ treatment of the source area was considered in detail during the detailed analysis of alternatives.

In evaluating the results of the modeling efforts, especially the multi-well pump-and-treat scenarios which were modeled for a 100-year time period, it is important to note an inherent limitation of the solute transport model developed for the Dublin site. Specifically, the model does not account for any transport mechanisms that retard contaminant migration; nor does the model account for contaminant mass confined within the bedrock matrix and isolated pore spaces. In reality, the TCE contamination has had over 30 years to migrate downgradient and disperse into the fractures and pore spaces of the bedrock aquifer. The result of this historical contaminant migration is the presence of TCE in the bedrock in both mobile and immobile fractions. In other words, a percentage of the contaminant mass is associated with the pore spaces of the bedrock media. Because many of these pore spaces are not interconnected, the actual timeframe for cleaning up the ground water to MCLs will be limited by the slow process of mass transfer from the immobile fraction to the more mobile fraction associated with ground water flow through the fracture network. Consequently, because the model treats the bedrock aquifer as a homogeneous porous medium, the model <u>may</u> overestimates the effectiveness of "pump-and-treat" technology in restoring ground water quality to MCLs. <u>Additional "real world" conditions that are not</u>

considered by the solute transport model are contaminant degradation (although empirical sampling data does not indicate that this is a significant factor at the site) and contaminant retardation. Contaminant degradation, if it is found to be occurring at the site, would accelerate the effectiveness of "pump-and-treat" technology. EPA has agreed that the solute transport model is not a true representation of natural conditions. Accordingly, the model is primarily being used to assist in the comparison of alternatives.

4.4 DESCRIPTION OF REMEDIAL ALTERNATIVES

Initial Alternatives

This section presents a description of the remedial alternatives assembled from the technologies and process options retained during the screening process that were subjected to a detailed evaluation. Six comprehensive alternatives were developed (although additional remedial scenarios were modeled to assess performance - see Section 4.3). These alternatives are summarized in Table 5. All of the alternatives involve some combination of ground water recovery, institutional controls and long-term ground water monitoring. In addition, several alternatives incorporate either in-situ or ex-situ treatment of the contaminant source area (i.e., at the 120 Mill Street property) as a means of source control.

The following text provides the rationale for selection of specific technologies retained from the technology/process option screening evaluations that served as the basis for assembling the six alternatives, and highlights the differences between the alternatives.

4.4.1 *Alternative 1 - No Further Action*

The NCP requires evaluation of a "no action alternative" to determine the need for remediation at a site and to serve as a baseline for all other alternatives to be compared. However, for sites where interim response action(s) have been implemented to address imminent risks to human health and the environment, the "no action alternative" is not an option. Rather, a "no further action" alternative, which acknowledges the remedial action(s) implemented via the interim response, becomes the baseline to determine the need for additional remediation and to compare other alternatives. As discussed in Section 1.2, OU1 was implemented as an "early action remedy" or interim response to provide a permanent clean drinking water supply for residences and businesses whose ground oxidants in contact with the TCE in the aquifer, which is directly related to subsurface conditions.

Three oxidants are available for in-situ treatment by chemical oxidation, specifically potassium or sodium permanganate solution, Fenton's reagent (i.e., hydrogen peroxide and iron catalyst solution), and ozone gas. Of these process options, a permanganate solution was identified as the most suitable for several reasons. Permanganate is more favorable with respect to material handling, operational concerns and health and safety. Also, permanganate does not degrade with time, so it remains available for oxidation until coming in contact with reactive materials.

Fenton's reagent and ozone were eliminated from further consideration for this alternative because these oxidants are problematic for subsurface injection. Fenton's reagent generates heat and gas, which can make the reaction difficult to control, thus creating operational and health and safety concerns. Also, the hydroxyl radicals generated by the reaction are relatively short-lived. Ozone is also problematic with respect to handling and operational concerns. Unreacted ozone gas escaping from the saturated zone can require use of a vapor collection and treatment, thus complicating its use.

Additional Alternatives

Following review of the draft FS by USEPA and PADEP, USEPA directed Sequa to incorporate within the FS three additional remedial alternatives. These additional alternatives are described in detail in the following sections. ~~It is important to note that these additional alternatives were not developed through the conventional FS process of screening candidate technologies and process options, and then assembling complete remedial alternatives based on the results of the technology screening. Instead,~~ These alternatives were identified by USEPA as scenarios that should be modeled to assess their performance with regard to the RAOs/expectations of source control and aquifer restoration. ~~Subjecting these alternatives to a detailed FS evaluation without the benefit of the technology screening process results in the identification of significant issues relative to several of the technology screening criteria (e.g., implementability and cost) (See Section 4.6).~~

4.4.7 *Alternative 4C - Pumping OU1 Supply Well @ 40 gpm and a Source Area Well @ 20 gpm*

Conceptually, Alternative 4C is the same as Alternative 4 except for the higher pumping rate of the source area well. The pumping rate for the source area well would be increased from 5 gpm to 20 gpm to achieve complete hydraulic containment of source material (i.e., the portion of the TCE plume with concentrations greater than or equal to 10 ppm). Complete hydraulic containment of the source material in the vicinity of the 120 Mill Street property is intended to facilitate restoration of the remaining portion of the aquifer beyond the source area.

Ground water recovered from the source area well near 120 Mill Street will require treatment prior to discharge. In contrast with Alternative 4, the higher pumping rate for this alternative will produce four times as much water to be treated and discharged. Of the two ex-situ treatment technologies (i.e., air stripping and chemical oxidation using permanganate) retained during the remedial technology screening step, air stripping was selected as the ex-situ treatment technology for this alternative. This technology would be cost-effective in removing a significant percentage of the contaminant mass from the ground water.

Communications with Dublin Borough indicate that the maximum available capacity of the Borough's municipal wastewater collection and treatment system is approximately 14,000 gpd, which is equivalent to approximately 10 gpm. Consequently, discharge of the effluent to the POTW (as was recommended for Alternative 4) is not a viable option for Alternative 4C. (Additionally, the capital cost necessary to expand the capacity of the POTW, in conjunction with routine sewer use fees, causes this option to be excessively costly in comparison to direct discharge.) The effluent from the treatment system would therefore need to be discharged either to a surface water that has adequate hydraulic capacity to receive the additional flow to avoid localized flooding, or possibly to the Dublin Borough municipal storm sewer system. The nearest surface water that is considered to have sufficient hydraulic capacity is Morris Run, located approximately one mile to the west/southwest of the 120 Mill Street property. Communications with Dublin Borough indicated that it would be acceptable to discharge the treated effluent to the Borough's storm sewer system, which runs within approximately 100 feet of the 120 Mill Street property. Evaluation of design information for the storm sewer system provided by the Borough indicated that the storm sewer system, which consists of a series of buried culverts and open vegetated swales, has sufficient hydraulic capacity to receive the effluent from the treatment system without compromising the system's ability to convey stormwater from peak events. For purposes of facilitating the connection of the discharge pipe to the storm sewer and for routine monitoring of the effluent, it is assumed that a junction manhole would be required. ~~To minimize the need for private property access, the effluent pipeline would be routed along public roadways to the maximum extent practicable. It is also possible that a pumping station would be required to convey the treated effluent to Morris Run.~~

Direct discharge of the treated effluent (either to Morris Run or the storm sewer) would be in accordance with the requirements of an NPDES permit (although an actual permit would not be needed). Discharge limits for a direct discharge would be much more stringent than for the indirect discharge to the POTW contemplated in Alternative 4. Consequently, additional treatment of the effluent following treatment via the air stripper would likely be required. Typically, "effluent polishing" is accomplished via treatment with activated carbon, although additional metals treatment may also be required to meet direct discharge limits.

4.4.8 *Alternative 7 - Pumping a Source Area Well at 20 gpm, Reducing the Pumping of the OU1 Supply Well from 40 gpm to 20 gpm, and ~~a~~ Pumping Three Downgradient Wells (each at 5 gpm)*

This alternative, which includes components of prior Alternatives 4C and Alternative 5, includes five recovery wells that achieve a combined total ground water withdrawal of 55 gpm from the contaminated portion of the bedrock aquifer as follows:

- a source area well pumping at 20 gpm to achieve complete hydraulic containment of source material (i.e., the portion of the plume with TCE concentrations greater than or equal to 10 ppm);
- reducing the pumping rate of the OU1 supply well from the 40 gpm pumping rate specified in the Record of Decision for OU1 to 20 gpm to minimize the effect OU1 has on the re-distribution of higher concentrations of TCE within the existing areal extent of the plume; and
- pumping three downgradient recovery wells (i.e., locations EW-3, EW-5 and EW10 on Figure 1 in Appendix B-2) located between the source area well and the OU1 supply well at 5 gpm each to reduce TCE concentrations in the portion of the plume beyond the source area (i.e., the area of the plume with TCE concentrations less than 10 ppm).

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The combined pumping rate for the source area and three downgradient recovery wells will produce a combined flow rate of 35 gpm of contaminated ground water that must be collected, conveyed, treated and discharged. Because ground water withdrawal would exceed 10,000 gpd, review by DRBC would be required.

Since the concentration of TCE from the three downgradient recovery wells is expected to be in the range of 100 μg/l to 10,000 μg/l, the most viable discharge option is to convey the extracted ground water to the source area and treat it in the source area treatment system (i.e., treatment system for the source area well described in Section 4.4.7)[10]. Discharge to the Borough's water distribution system may not be well-received by the public, and could necessitate potentially significant upgrades to the OU1 treatment system. Individual direct discharges would require suitable discharge points (i.e., sufficient hydraulic capacity to avoid seasonal flooding) and would not be very cost effective even if technically feasible.

The differences between Alternative 7 and 4C in terms of conceptual design would be as follows:

- the source area treatment system and effluent pipeline would need to be sized to accommodate a total flow of 35 gpm rather than 20 gpm;
- three bedrock extraction wells would need to be installed (or constructed from existing wells) (assumed to be 6-inch diameter and approximately 450 feet in depth) (along with the acquisition of permanent property access ~~acess~~); and
- a collection and conveyance pipeline (i.e., manifold system) to route the extracted ground water from each of the three downgradient recovery wells to the source area treatment system would need to be constructed (along with the acquisition of permanent property access).

Additionally, because the OU1 well pumping rate would be reduced from its current rate of 40 gpm to 20 gpm, implementation of this alternative would require that the Borough adjust the pumping rate of other Borough

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[10] Even though this discharge option is considered to be the most viable option, it would likely require very conservative design measures (with resultant cost implications) because contaminated water would be conveyed throughout portions of the Borough (e.g., piping with secondary containment and leak detection). Additionally, the alternative would likely not be well-received by the community.

supply wells, if possible[11], or install a new supply well to meet the total water demand of the Borough.

4.4.9 *Alternative 8 - Pumping OU1 Supply Well @ 20 gpm and a Source Area Well @ 20 gpm, and 12 Downgradient Wells at 5 gpm*

Alternative 8 is intended to be an ~~extreme~~ aggressive pumping scenario to determine if aquifer restoration can be achieved at all. This alternative is the same as Alternative 7 except that the total number of downgradient wells would be increased from three to 12 wells located between the source area well and the OU1 supply well (see EW-1 through EW-12 on Figure 1 of Appendix B-2). Each of the 12 downgradient wells would be pumped at 5 gpm. Including the source area well and the OU1 supply well, this alternative would have a total of 14 recovery wells that achieve a combined total ground water withdrawal of 100 gpm from the bedrock aquifer. Because ground water withdrawal would exceed 10,000 gpd, review by DRBC would be required. DRBC ~~review/approval~~ could have ~~be~~ even more concerns ~~of an issue~~ (in comparison to prior alternatives - e.g., Alt #4C and 7) due to the ~~a~~ total withdrawal and volume of water unavailable for public use. ~~non-beneficial use of more than ten times (>10x) the allowable DRBC limit.~~

The combined pumping rate for the source area well and 12 downgradient wells would produce a combined flow rate of 80 gpm of contaminated ground water that must be treated and discharged. For the same reasons discussed in Section 4.4.8 for Alternative 7, the extracted ground water from the 12 downgradient recovery wells would be manifolded and conveyed to the source area treatment system. Also, similar to Alternative 7, the reduced pumping rate of the OU1 supply well would require the Borough to adjust the pumping rate of an existing supply well or install a new supply well to account for the loss of 20 gpm in the Borough's distribution system.

The differences between Alternative 8 and Alternative 7 in terms of conceptual design are as follows:

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[11] Note that the only existing supply well believed to have sufficient yield to accommodate a 20-gpm increase in pumping rate is Borough Well #3. The effects of increasing the pumping of Borough Well #3 on plume dynamics and its overall configuration were not evaluated in this study.

4.5.1.4 *Reduction of Toxicity, Mobility or Volume*

The "No Further Action" alternative achieves some limited reduction in toxicity, mobility and volume of the TCE plume. Toxicity is reduced by the OU1 treatment system (i.e., air stripper and vapor-phase carbon treatment) prior to use of the recovered ground water. The mobility and volume of the plume is reduced as a result of the hydraulic influence created in the bedrock aquifer by the OU1 supply well. ~~Solute transport modeling results indicate the OU1 supply well, which is located downgradient of the source area, captures and contains the leading edge of the plume, thus preventing continued plume migration to areas not impacted by the plume (i.e., beyond the current leading edge of the plume).~~ As a result of ground water recovery and treatment, contaminant mass is removed, but the amount of mass removed is small relative to the total mass contained in the plume. Natural attenuative processes (i.e., dispersion and dilution) are also likely to contribute to reduction of the toxicity, mobility and volume of the constituents of concern in some portions of the plume. The suspected DNAPL source and dissolved phase contamination at concentrations in excess of MCLs would remain in the bedrock aquifer after implementation of this alternative.

4.5.1.5 *Short-term Effectiveness*

The No Further Action alternative would not involve any remedial activities beyond O&M of the OU1 supply well/treatment system and ground water sampling. Consequently, there are no substantial short-term exposures to workers or the community associated with this alternative. The successful implementation of the OU1 water supply and treatment system, institutional controls and the ground water monitoring program identified in the OU1 ROD provide adequate short-term protection of human health.

4.5.1.6 *Implementability*

This alternative has already been successfully implemented (all components of the OU1 ROD were completed in 1999), and its continued operation does not require any additional engineering, construction or administrative measures. The technologies are reliable and additional remedial action, if necessary (e.g., upgrades to the OU1 treatment system), could be implemented relatively easily and without substantially affecting the interim response action.

Safe Drinking Water Act for the Borough or the Dublin Acres community is less than it would be for Alternatives 1 and 2.

4.5.3.3 *Long-term Effectiveness and Permanence*

This alternative would provide long-term effectiveness and permanence, and would be effective in meeting the RAOs for protection of human health and the environment, compliance with ARARs and prevention of plume migration. This alternative would not address the additional RAOs for source control or restoration of ground water to beneficial uses as predicted by the solute transport model. Residual contamination exceeding MCLs would remain in the bedrock aquifer after implementation of this alternative. The combination of a permanent and reliable water supply, additional institutional controls (i.e., deed restrictions), and a long-term ground water monitoring plan designed to support the remedy and assess future conditions would effectively address current and future risks.

Ground water modeling results indicate this alternative is likely to prevent migration of the plume. Although this alternative would not reduce the lateral extent of the plume, the hydraulic influence of the OU1 supply well appears to prevent further migration of the plume downgradient of the OU1 well. A time versus concentration graph for TCE (see Attachment 2 of Appendix B1) indicates this alternative would prevent TCE concentrations from approaching the MCL at the Dublin Acres wells (and nearby Dublin Borough Well No. 3) located downgradient of the OU1 supply well. Additionally, this alternative is predicted to result in reduced concentrations of TCE (in comparison to Alternative 1) reaching the OU1 supply well. Increased pumping of the OU1 supply well is predicted to have the effect of diluting contamination by pulling more clean water from the portion of the aquifer to the north that has not been impacted by TCE.

4.5.3.4 *Reduction of Toxicity, Mobility or Volume*

Alternative 3 would reduce the toxicity, mobility or volume of the TCE plume in the same manner as described for Alternative 2. The higher pumping rate for the OU1 supply well would exert hydraulic influence over a larger area of the aquifer, thus capturing a greater portion of the leading edge of the plume. Although the higher pumping rate for this well would likely increase the contaminant mass removed from the plume; the mass removed would still be minimal relative to the total mass contained in the plume. In addition, due to preferential capture of clean water from portions of the aquifer not impacted by TCE (as discussed in 4.5.3.3 above), the additional amount of contaminated ground water removed in comparison to Alternatives 1 and 2 would be minimal. Also, the suspected DNAPL source and dissolved phase contamination would remain in the bedrock aquifer at levels exceeding MCLs after implementation of this alternative.

4.5.3.5 *Short-term Effectiveness*

This alternative would not involve any additional remedial activities (in comparison to Alternative 2) other than possible installation of a new submersible pump to handle the increased pumping rate. Consequently, there would be no substantial short-term exposures to workers or the community associated with this alternative. The OU1 alternate water supply and treatment system, in conjunction with existing institutional controls and ground water monitoring, would provide adequate short-term effectiveness.

4.5.3.6 *Implementability*

This alternative could successfully be implemented from an administrative and technical perspective. Most of the components of this alternative have already been implemented as the response action for OU1. The additional components (i.e., additional institutional controls, modifying the ground water monitoring program and upgrading the OU1 supply well to increase the pumping rate) could be readily implemented. Prior testing of the OU1 supply well indicated a potential maximum yield of 75 gpm (CH2M Hill, 1994). The additional water provided by the increased pumping of the OU1 supply well would be discharged to the municipal water supply distribution system thereby meeting the total current demand of the Borough. This would allow the Borough to take existing supply wells #1,# 2, and #3 out of routine production and use these wells for backup supply.

4.5.3.7 *Cost*

Table 3 of Appendix C (Detailed Cost Estimates) presents a detailed breakout of the estimated costs for Alternative 3 (including significant assumptions). The total estimated costs for this alternative are:

Initial Capital Cost	$ 21,600
Annual O&M (Years 1 through 5)	$ 50,400

without impacting the remedial components already in place. With respect to administrative feasibility, implementation of this alternative would be contingent on obtaining access to private property. Such access would be required in a suitable location downgradient of the source area to either install a new recovery well or utilize an existing well to serve as the downgradient well. And based on prior experience, obtaining access for a suitable location (to be determined based on areal location and well yield) could be difficult and could have a bearing on cost. Materials and services to implement this alternative are readily available.

4.5.5.7 *Cost*

Table 5 of Appendix C (Detailed Cost Estimates) presents a detailed breakout of the estimated costs for Alternative 5 (including significant assumptions). The total estimated costs for this alternative are:

Initial Capital Cost	$ ~~71,100~~ 314,000
Annual O&M (Years 1 through 5)	$ 52,300
Annual O&M (Years 6 through 30)	$ 30,400
Net Present Value (30 years at 7%)	~~$538,100~~ 781,100

4.5.5.8 *State Acceptance*

This criterion will be evaluated during review of the FS by PADEP.

4.5.5.9 *Community Acceptance*

This criterion will be evaluated during review of the PRAP (i.e., public comment period).

4.5.6 *Alternative 6 - OU1 (at 40 gpm) and Source Area In-situ Treatment*

4.5.6.1 *Overall Protection of Human Health and the Environment*

Alternative 6, which includes the most aggressive source treatment measure of all alternatives evaluated -- in-situ treatment to achieve an assumed 75% reduction in the source area concentrations -- would provide only an acceptable level of protection of human health and the environment. Although in-situ treatment would result in a significant reduction in source area concentrations, significant levels of TCE (i.e., well above the MCL) would still remain throughout the plume. Time vs. concentration graphs generated from the modeling results (see Attachment 8 of Appendix B1) indicate that the potential exists for

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concentrations above the MCL to reach the Dublin Acres and Borough Well #3 supply wells in the future. In conjunction with this potential long-term risk, Alternative 6 has a higher level of risk associated with its implementation (see Section 4.5.6.5 -- short-term effectiveness).

4.5.6.2 *Compliance with Potential ARARs*

Alternative 6 is considered to be compliant with all ARARs. The in-situ treatment contemplated by Alternative 6 would eliminate the need for pretreatment and a discharge permit for discharges to the POTW or treatment/permitting associated with air emissions. Like other alternatives considered in this FS, however, and despite the implementation of what is viewed as a very aggressive treatment technology, concentrations of TCE above the MCL are predicted to persist throughout most of the plume for at least 30 years. Therefore, this alternative would not achieve drinking water standards within a reasonable timeframe; rather, the eventual (i.e., indefinite) cleanup of ground water to drinking water standards would only occur via the continued operation of the OU1 supply well/treatment system in conjunction with natural attenuative processes.

4.5.6.3 *Long-term Effectiveness and Permanence*

This alternative would provide long-term effectiveness and permanence, and would be effective in meeting the RAOs for protection of human health and the environment, compliance with ARARs and prevention of plume migration. This alternative would also address the additional RAO of source control, although the degree of source control may not be complete (i.e., residual source strength material would likely remain in the bedrock aquifer after treatment is completed). The combination of a permanent and reliable water supply, additional institutional controls, long-term ground water monitoring, and in-situ treatment for source control would address current and future risks. Residual contamination exceeding MCLs would remain in the bedrock aquifer after implementation of this alternative; therefore, the RAO/expectation of restoring the aquifer to beneficial use (i.e., drinking water supply) would not be achieved within a reasonable timeframe, as predicted by the solute transport model.

In-situ treatment of the source area would reduce source area concentrations of contaminants in ground water near the 120 Mill Street property, which would address at least to some degree, the RAO for source control. As indicated by the ground water modeling results (see concentrations of TCE beyond the immediate vicinity of the borehole so that greater oxidation of TCE would occur in the source area. Although the oxidation efficiency of the permanganate solution is relatively high, it is anticipated that multiple injection events would be necessary to observe a substantial decrease in source strength concentrations. Pre- and post-monitoring would be required for each injection event to monitor the effectiveness of the treatment process.

4.5.6.7 *Cost*

Table 6 of Appendix C (Detailed Cost Estimates) presents a detailed breakout of the estimated costs for Alternative 6 (including significant assumptions). The total estimated costs for this alternative are:

Initial Capital Cost	$264,800
Annual O&M (Years 1 through 5)	$ 43,900
Annual O&M (Years 6 through 30)	$ 22,000
Net Present Value (30 years at 7%)	$627,600

4.5.6.8 *State Acceptance*

This criterion will be evaluated during review of the FS by PADEP.

4.5.6.9 *Community Acceptance*

This criterion will be evaluated during review of the PRAP (i.e., public comment period).

4.6 *EVALUATION OF ADDITIONAL ALTERNATIVES*

As mentioned previously, following review of the draft FS by USEPA and PADEP, USEPA directed Sequa to incorporate three additional remedial alternatives into the FS. These additional alternatives are described in detail in Section 4.4 and are evaluated in the following sections. ~~It is important to note that these additional alternatives were not developed through the conventional FS process of screening candidate technologies and process options, and then assembling complete remedial alternatives based on the results of the technology screening. Instead,~~ These alternatives were identified by USEPA as scenarios that should be modeled to assess their performance with regard to the RAOs/expectations of source control and aquifer restoration. ~~Subjecting these alternatives to a detailed FS evaluation without the benefit of the~~

~~technology screening process results in the identification of significant issues relative to several of the technology screening criteria (e.g., implementability and cost).~~

4.6.1 Alternative 4C[13] - OU1 (at 40 gpm) and a Source Area Well (at 20 gpm)

4.6.1.1 *Overall Protection of Human Health and the Environment*

Similar to Alternative 4, Alternative 4C would provide a very good level of human health protection. In addition to OU1, which effectively addressed any imminent risks to human health and the environment, complete hydraulic containment of source material would effectively eliminate the continued migration of high levels of contamination and thereby reduce the maximum contaminant concentrations expected to reach the OU1 supply well, the Dublin Acres community wells, and Dublin Borough Well #3. However, in contrast to Alternative 4, which contemplated discharge of the extracted ground water to the POTW, Alternative 4C entails direct discharge of the extracted ground water from the source area (following treatment) to ~~Morris Run~~ the municipal storm sewer system. Therefore, additional risks could result via exposures to ~~Morris Run~~ surface water (by human or ecological receptors) if upsets to the treatment system were to occur.

4.6.1.2 *Compliance with Potential ARARs*

Alternative 4C is expected to be compliant with all ARARs. Due to the reduced contaminant concentrations expected to reach the water supply wells of Dublin Borough (i.e., OU1 and Well #3) and the Dublin Acres community wells, compliance with the Safe Drinking Water Act should not be an issue.

However, in contrast to Alternative 4, direct discharge of the effluent to the ~~Morris Run~~ municipal storm sewer system (rather than indirect discharge to the POTW under Alternative 4) increases the level of treatment required and heightens the need for effective treatment. Discharge to ~~Morris Run~~ the storm sewer would be in accordance with the discharge limits and monitoring terms of an NPDES permit. And although compliance is expected, there is a greater possibility of non-compliance under Alternative 4C than Alternative 4 due to the more

[13] The reader is referred to Appendix B1 for a discussion of Alternatives 4A and 4B.

This alternative would also remove contaminant mass due to the pumping of a well within the source area, along with the downgradient pumping of the OU1 supply well. However, the suspected DNAPL source and dissolved-phase contamination would remain in the bedrock aquifer at levels exceeding MCLs for an extended period time (e.g., >30 years in the vicinity of the OU1 supply well).

4.6.1.5 *Short-Term Effectiveness*

As with Alternative 4, Alternative 4C would involve installation of a new recovery well or reconstruction of an existing well at the 120 Mill Street property, routine O&M of the source area recovery well and treatment system, along with routine O&M of the OU1 well and treatment system. In contrast to Alternative 4, Alternative 4C would entail ~~the construction of an effluent pipeline from the 120 Mill Street site to Morris Run (approximately one mile)~~ discharge to the Dublin Borough municipal storm sewer system rather than the Borough's POTW (i.e., a direct rather than indirect discharge). There is potential for adverse short-term effects to construction workers due to the increased potential for exposure to DNAPL concentrations of TCE during construction/reconstruction of the recovery well and during construction of the on-site treatment system. ~~There is also an increased risk to public health and environmental receptors from possible leaks or breaches in the effluent pipeline. Finally, any upsets in the treatment system would result in~~ In addition, there is also a greater potential (in comparison to alternatives involving discharge to the POTW) for adverse short-term effects to water quality and ecological receptors ~~in Morris Run~~ from possible upsets in the treatment system.

4.6.1.6 *Implementability*

The pumping test conducted during the RI showed that the Fire Tower Well has a sustainable yield of at least 25 gpm so there should be no problem in pumping a source area well (possibly the Fire Tower Well) at a continuous rate of 20 gpm. Although treatment of the extracted ground water would be possible, the level of treatment required (and therefore the costs) would be significantly greater than that required either for the OU1 supply well or that contemplated in Alternative 4 due to the concentration of contaminants and the more stringent discharge requirements (i.e., direct vs. indirect discharge). In addition to stringent discharge limits, all other substantive aspects of an NPDES permit would also apply to the direct discharge of the extracted ground water to ~~Morris Run~~ the municipal storm sewer system. Finally, Alternative 4C would require the construction of an approximate one-mile effluent pipeline, which would necessitate substantial coordination with other agencies (including Hilltown Township and DRBC - see Section 2.2.2.5) and acquisition of numerous rights-of-ways or easements.

4.6.1.7 *Cost*

Table 7 of Appendix C (Detailed Cost Estimates) presents a detailed breakout of the estimated costs for Alternative 4C (including significant assumptions). The total estimated costs for this alternative are:

Initial Capital Cost	$ ~~205,100~~ 105,200
Annual O&M (years 1 through 5)	$ 88,700
Annual O&M (years 6 through 30)	$ 66,800
Net Present Value (30 years at 7%)	~~$1,123,800~~ 1,023,900

4.6.1.8 *State Acceptance*

This criterion will be evaluated during review of the FS by PADEP.

4.6.1.9 *Community Acceptance*

This criterion will be evaluated during review of the PRAP (i.e., public comment period).

4.6.2 ***Alternative 7 - Source Area Well at 20 gpm, Reduced Pumping of the OU1 Well (20 gpm), and Three Downgradient Recovery Wells (5 gpm each)***

4.6.2.1 *Overall Protection of Human Health and the Environment*

Alternative 7 is protective of human health and the environment to the same extent as Alternative 4C, with several notable exceptions. The similarities are: 1) the successful implementation of the OU1 remedy has effectively addressed any imminent risks to human health and the environment; 2) complete hydraulic containment of source material would effectively eliminate continued migration of high levels of contamination, thereby reducing the maximum concentration of contaminants expected to reach the OU1 supply well; and 3) the direct discharge of the extracted ground water from the source area to ~~Morris Run~~ the storm sewer (following treatment) could result in exposures to ~~Morris Run~~ contaminants in surface water (by human or ecological receptors) if upsets to the treatment system were to occur.

TCE-impacted ground water (i.e., 1-5 mg/l) would extend approximately 1,500 feet downgradient in Model Layer 5 after 100 years. Table 6 presents the model-predicted TCE concentrations for each model layer, for select locations throughout the plume, and for select time intervals up to 100 years. In addition, Table 6 also presents the model-predicted timeframe for achieving MCLs, if feasible, at select locations throughout the plume.

With regard to the permanence of Alternative 7, it will remain protective of human health and the environment due to the successful implementation of the OU1 remedy. However, it is important to note that the effectiveness in achieving source control and the extent of aquifer restoration predicted to be achieved are contingent upon the continuous and indefinite pumping of the source control well. Otherwise, high-strength contamination would migrate from the source area and recontaminate those portions of the aquifer where restoration is predicted to occur.

4.6.2.4 *Reduction of Toxicity, Mobility or Volume*

Like Alternative 4C, Alternative 7 would significantly reduce the mobility of high strength contamination by achieving complete hydraulic control of the source area. Complete hydraulic control of source material would also significantly reduce the volume of ground water contamination by eliminating the continued migration of dissolved-phase TCE beyond the source area.

However, as discussed in 4.6.2.2 above, the reduced pumping of the OU1 supply well appears to have off-setting effects in terms of contaminant mobility. One, it contributes to greater control (i.e., limited migration) of source material and high-strength contamination proximal to the source area. But it also appears to result in increased migration (mobility) of lower levels of contamination, with the consequence of potentially experiencing MCL exceedances at the Dublin Acres community wells and Dublin Borough Well #3.

4.6.2.5 *Short-Term Effectiveness*

The short-term effectiveness of Alternative 7 is deemed to be similar to that of Alternative 4C. All imminent risks to human health have been effectively addressed via the successful implementation of the OU1 remedy. However, the potential for worker exposure exists during the construction of the source area well and treatment system. ~~Additionally, there would be increased risks to the public and ecological receptors from~~

~~either breaches in the effluent pipeline and/or upsets in the treatment system that could cause elevated contaminant concentrations to reach Morris Run.~~ Similar to Alternative 4C, there is a potential for adverse effects to human health or ecological receptors in the event of any upsets to the treatment system due to the fact that the effluent from the treatment system is discharged directly to the storm sewer system (in contrast to indirect discharge to the POTW). Additionally, and in comparison to Alternative 4C, the potential for adverse impacts to human health or the environment could result from breaches in the ground water collection and conveyance system (though the likelihood of such an incident is considered low). The timeframe required to complete the implementation of Alternative 7 would be expected to be longer than Alternative 4C due to the need to acquire permanent property access and install three downgradient recovery wells and a collection/conveyance system.

4.6.2.6 *Implementability*

The implementability of Alternative 7 is also assessed to be identical to Alternative 4C, with one notable exception. The ability to obtain permanent access, either via easements or outright purchase, of appropriate properties (i.e., locations) to install the downgradient recovery wells is uncertain. The difficulties encountered during the RI for installation of monitoring wells, which only required finite access, are expected to be worse for obtaining access to construct and operate recovery wells indefinitely. For these reasons, outright purchase of the necessary properties was assumed for cost estimating purposes (see Appendix C). The potential property access issue would be further compounded by the need to convey contaminated ground water across multiple properties to the treatment system located at the source area.

4.6.2.7 *Cost*

Table 8 of Appendix C (Detailed Cost Estimates) presents a detailed breakout of the estimated costs for Alternative 7 (including significant assumptions). The total estimated costs for this alternative are:

Initial Capital Cost	$ ~~1,027,900~~ 636,500
Annual O&M (years 1 through 5)	$ 99,100
Annual O&M (years 6 through 30)	$ 77,200
Net Present Value (30 years at 7%)	~~$2,075,700 NF[14]~~ ≥ 1,684,300[14]

4.6.2.8 State Acceptance

This criterion will be evaluated during review of the FS by PADEP.

4.6.2.9 Community Acceptance

This criterion will be evaluated during review of the PRAP (i.e., public comment period).

4.6.3 Alternative 8 - Source Area Well (at 20 gpm), Reduced Pumping of the OU1 Well (20 gpm), and Twelve Downgradient Recovery Wells (at 5 gpm each)

4.6.3.1 Overall Protection of Human Health and the Environment

Alternative 8 is protective of human health and the environment to the same extent as the other alternatives (due to the successful implementation of the OU1 remedy). Via modeling simulations, Alternative 8 is predicted to restore the aquifer to the greatest extent of all the alternatives evaluated. This implies that the residual risk would be less than for all other alternatives; however, it is important to note that the restoration (and therefore risk reduction) achieved by this alternative (as well as the other additional alternatives evaluated) is contingent upon continuous and indefinite operation of the source control well and possibly the downgradient recovery wells. Additionally, high strength contamination (including DNAPL) would remain within the source area indefinitely, although a combination of engineering and institutional controls would be effective in eliminating exposure to contamination within the source area.

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[14] ~~NF = Not feasible. Estimated costs likely reflect the lower end of a cost range; due to numerous implementability issues, the upper end of the cost range would be the conclusion that the alternative is not implementable at any cost.~~ In comparison to the other alternatives evaluated, the complexity of design associated with this alternative causes the estimated cost to be less accurate than the other cost estimates and, in all likelihood, reflects the lower end of a cost range.

It is also noted that, similar to Alternative 7, the need to collect and convey contaminated ground water throughout portions of the Borough introduces another source of risk to human health and the environment, but to an even greater extent than Alternative 7.

4.6.3.2 *Compliance with Potential ARARs*

Like all of the other alternatives evaluated, Alternative 8 is expected to be compliant with all ARARs. The enhanced aquifer restoration afforded by the twelve downgradient recovery wells results in model predictions that MCLs should not be exceeded at any time in the future at the OU1 supply well, the Dublin Acres community wells, or Dublin Borough Well #3; therefore compliance with the Safe Drinking Water Act should not be an issue.

However, similar to Alternatives 4C and 7, direct discharge of the treated effluent from the source area treatment system to ~~Morris Run~~ the storm sewer increases the potential for violations of the Clean Water Act (in comparison to alternatives that involve indirect discharge of the treated effluent ~~any of the initial alternatives evaluated~~).

4.6.3.3 *Long-Term Effectiveness and Permanence*

Alternative 8 is effective in terms of meeting the threshold criteria of being protective of human health and the environment and being compliant with ARARs. Alternative #8 also provides the greatest effectiveness of all alternatives evaluated relative to the additional RAOs/expectations of source control and aquifer restoration. As expected, model simulations (see Appendix B2) indicate that the incorporation of twelve downgradient recovery wells, in conjunction with the other components of Alternative 8, removes the greatest amount of contaminant mass in less time than any of the other alternatives evaluated.

Despite the extent of aquifer restoration predicted, complete restoration of the aquifer to its beneficial use is still not predicted to occur by the solute transport model, even though as discussed in Section 4.3 the model overestimates the actual effectiveness of pump-and-treat technology in a bedrock aquifer. Specifically, the model predicts that TCE impacted ground water with a peak concentration of 100 μg/l would extend approximately 500 feet downgradient of the source area in Model Layer 2 after 30 years of remedial pumping, and TCE-impacted ground water (i.e., 1-5 μg/l) would extend approximately 1,400 feet downgradient of the source area in Model Layer 5 after 100 years (see Appendix B2). Table 6 presents the model-predicted TCE concentrations for each model layer, for select locations throughout the plume, and for select time intervals up to 100 years. In addition, Table 6 also presents the model-predicted timeframe for achieving MCLs at select locations throughout the plume.

With regard to the permanence of Alternative 8, as noted previously for Alternatives 4C and 7, the extent of aquifer restoration predicted to be achieved by Alternative 8 is contingent upon the continuous and indefinite pumping of the source control well.

4.6.3.4 *Reduction of Toxicity, Mobility or Volume*

Alternative 8 reduces the mobility and volume of ground water contamination to the greatest extent in comparison to all other alternatives evaluated. As with Alternative 7, this reduction in contaminant mobility and volume is achieved through a combination of complete source control and a number of downgradient recovery wells. However, because the reduction in contaminant mobility and volume is contingent upon the continuous and indefinite pumping of these wells, especially the source control well, the beneficial effects of Alternative 8 are considered reversible - i.e., high strength contamination would be expected to migrate from the source area and recontaminate those portions of the aquifer where restoration is predicted to occur should the source area well (and possibly some or all of the downgradient recovery wells) cease operation.

4.6.3.5 *Short-Term Effectiveness*

The short-term effectiveness of Alternative 8 is deemed to be ~~identical~~ similar to that of Alternative 4C and 7 (see Sections 4.6.1.5 and 4.6.2.5). A distinction between Alternative 8 and Alternatives 4C and 7 would be that the likelihood of a breach in the ground water collection and conveyance system would be slightly higher (though still considered an unlikely event) due to the increased complexity and length of piping required to collect the contaminated ground water from the 12 extraction wells. It is also noted~~, however,~~ that the timeframe for implementing the alternative, due to the anticipated difficulties related to obtaining property access, would be even longer than that for Alternative 7.

4.6.3.6 *Implementability*

The implementability of Alternative 8 is assessed to be very similar to Alternative 7. The only difference is the number of properties required for the installation/construction of the downgradient recovery wells, and the collection/conveyance piping would be roughly four times greater for Alternative 8 than Alternative 7. ~~If possible at all, t~~The time and costs (see Section 4.6.3.7) required to obtain the necessary property access are considered to be ~~excessive in comparison to~~ significantly greater than the total implementation timeframe and costs for other alternatives evaluated.

4.6.3.7 *Cost*

Table 9 of Appendix C (Detailed Cost Estimates) presents a detailed breakout of the estimated costs for Alternative 8 (including significant assumptions). The total estimated costs for this alternative are:

Initial Capital Cost	~~$4,699,200~~ 2,807,200
Annual O&M (years 1 through 5)	$ 118,800
Annual O&M (years 6 through 30)	$ 96,900
Net Present Value (30 years at 7%)	~~$5,991,400 NF[15]~~ $\geq$ 4,099,400[15]

4.6.3.8 *State Acceptance*

This criterion will be evaluated during review of the FS by PADEP.

4.6.3.9 *Community Acceptance*

This criterion will be evaluated during review of the PRAP (i.e., public comment period).

[15] See Footnote 14.

5.0 *COMPARATIVE ANALYSIS OF ALTERNATIVES*

The following section provides a comparative analysis of the nine candidate remedial alternatives (i.e., six initial alternatives and three additional alternatives incorporated at USEPA's direction) based on the results of the detailed evaluation of the alternatives against the nine evaluation criteria presented in Section 4. Consistent with USEPA guidance (USEPA, 1988), this FS does not recommend a particular alternative, but rather via this comparative analysis provides an objective evaluation of the alternatives within the context of the nine evaluation criteria identified in the NCP. Table 7 summarizes the results of this comparative analysis.

~~Note that the three alternatives added at USEPA's direction were not developed in accordance with USEPA guidance (ref. USEPA, 1988), but rather were added to the detailed evaluation of alternatives at the direction of USEPA. Accordingly, these alternatives consist of component technologies or process options that may not have survived the technology screening process of a conventional FS. At the least, when subjected to a detailed evaluation, significant issues are raised relative to several of the technology screening criteria (e.g., "implementability" and "cost"). Nevertheless, the level of detailed evaluation performed is considered sufficient for conducting a comparative analysis of these alternatives relative to other candidate alternatives. However, if these alternatives are considered beyond this FS, additional detailed analysis would be required to confirm their feasibility and implementability.~~

Several general observations made as a result of the comparative analysis are as follows:

- All alternatives satisfy the threshold criterion of being protective of human health and the environment under current conditions, and the combination of institutional controls and routine monitoring provide protection in the future;

- All alternatives are also expected to be fully compliant with all potential ARARs; however, due to the need for a direct discharge of the effluent from a source area treatment system under Alternatives 4C, 7 and 8, there would be an increased potential for violations of the Clean Water Act (CWA). Additionally, the collection and conveyance of contaminated ground water through portions of the Borough under

Alternatives 7 and 8 would also result in an increased potential for CWA violations.

- None of the alternatives is predicted to completely achieve the USEPA expectation of restoring the aquifer (excluding the source area) to drinking water quality within a reasonable timeframe (i.e., $\leq$ 30 years). Alternative 8 restores the greatest percentage of the aquifer within the shortest timeframe, but is contingent upon continuous and indefinite pumping of a source control well. Only natural attenuative processes will result in the complete restoration of the aquifer;

- The implementability of Alternative 8 (the most ~~extreme~~ aggressive pumping scenario modeled and the alternative that is predicted by the ground water model to restore the aquifer to the greatest extent) is extremely questionable, and its costs are considered excessive in comparison to the other alternatives;

- Due to the need to acquire a number of permanent property accesses under Alternatives 7 and 8, the time required to complete implementation of these alternatives is expected to be significantly longer than the other alternatives evaluated;

- The reduced pumping of the OU1 supply well contemplated in Alternatives 7 and 8 results in increased migration of contamination in the vicinity of several receptor supply wells downgradient of the OU1 well; and

- The expedited restoration of the aquifer that is predicted to occur in the more ~~extreme~~ aggressive alternatives (e.g., Alternatives 7 and 8) is contingent upon the condition that all recovery wells, especially the source control well, would need to pump continuously and indefinitely. Otherwise, high-strength contamination would migrate from the source area and recontaminate those portions of the aquifer where restoration is predicted to occur.

An overarching observation relates to the fact that the Site is characterized by only one media of concern - ground water. Therefore, predictive ground water modeling is the means by which future conditions can be simulated and evaluated. The ground water flow and solute transport models used during this FS have proven to be reliable models for predicting future ground water conditions and the performance of remedial systems at numerous Superfund and other sites with ground water contamination. However, the ability of solute transport models to accurately simulate the effectiveness of pump-and-treat technology in restoring ground water quality in bedrock aquifers is limited. Therefore, due to the uncertainties common to all ground water modeling, especially under the conditions that exist at the Dublin site, decisions regarding the need for remediation and distinctions between remedial scenarios should be based upon empirical data to the maximum extent practicable (i.e., past and future ground water monitoring results).

5.1 *COMPARISON OF THRESHOLD CRITERIA*

As shown on Table 7, the threshold criteria are: *overall protection of human health and the environment* and *compliance with ARARs.*

Each of the alternatives meets the threshold criterion of being protective of human health and the environment. This is primarily because OU1 (i.e., Alternative #1), which had as its objective providing a reliable source of potable water to all residences and businesses whose supply wells had been or could potentially be impacted by contaminated ground water, was successfully implemented, thereby eliminating all risks under current conditions. And based on the findings of the RI and BLRA, the successful implementation of OU1, which includes existing institutional controls and a long-term monitoring program, is projected to be protective of human health and the environment under future conditions for the areas currently served by the OU1 water line.

The primary distinction between the alternatives with regard to protection of human health and the environment relates to the maximum contaminant concentrations predicted to reach certain downgradient supply wells in the future - specifically, Borough supply wells #3 and #5 (OU1), and the Dublin Acres community wells. Alternatives 1, 2 and 6 are the only alternatives where the temporal trend after 30 years does not assure that MCLs would not be exceeded at the potential receptor wells downgradient of the OU1 supply well; however, ~~asymototic~~ asymptotic trends are indicated, which means that the maximum concentrations predicted to occur at these locations are not expected to be significantly higher than the MCL. Also, due to the reduced pumping of the OU1 supply well in Alternative 7, concentrations of TCE approaching the MCL are predicted to reach the downgradient supply wells after approximately 30 years. Alternative 5 is predicted to result in increased lateral spread of the contaminant plume in comparison to the other alternatives, which could result in an increased potential for exposures beyond the current public water distribution system. All other alternatives are considered to be fully protective of potential receptor wells without reservation (based on the predictions of the solute transport model).

Although all alternatives are expected to be fully compliant with all potential ARARs, an increased potential for non compliance with several ARARs exists for several of the alternatives evaluated. Potential non-compliance with the Safe Drinking Water Act would result from concentrations of TCE reaching several supply wells downgradient of the OU1 well - specifically, Borough Well #3 and the Dublin Acres community supply wells. This potential for non-compliance with an ARAR was discussed above as it relates to overall protection of human health and the environment.

It should be noted, however, that the potential for exceeding MCLs was identified based on the TCE concentrations predicted by the solute transport model to reach those well locations in the future (10 to 30 years in the future). As discussed in Section 4.5, the modeling prediction that a concentration of TCE above the MCL at a well point would not necessarily result in an exceedance of the MCL in the water supply well or public distribution system due to the volume of clean water within the well's capture zone and the volatilization that would occur within the well. Additionally, it should be noted that well head treatment (or treatment upgrades in the case of the OU1 system) could be easily implemented to ensure compliance with the SDWA at these locations.

Another potential for non-compliance with an ARAR that warrants discussion is the increased potential for non-compliance with the Clean Water Act (CWA) which could result from exceedances of the direct-discharge limits for Alternatives 4C, 7 and 8. These three alternatives, which were incorporated into the FS at the direction of USEPA following their review of the draft FS, are the only alternatives which require a direct discharge of treated ground water to surface water. The volume of ground water being extracted in these alternatives exceeds the hydraulic capacity of the POTW and therefore direct discharge to ~~Morris Run~~ to the municipal storm sewer system are considered ~~via an approximate one-mile pipeline was considered~~ the best discharge option[16]. The stringent discharge limits of a direct discharge (i.e., NPDES permit conditions) in combination with the high levels of contamination within the contaminant source area, emphasizes the need for an appropriately designed and

[16] See Footnote #4.

of this alternative was the possible need to change the OU1 well pump to achieve the higher pumping rate, along with the possibility of other minor modifications to the existing OU1 recovery/treatment system.

All other alternatives, except Alternative 6, were viewed less favorably in terms of the short-term effectiveness criterion because they involve additional ground water recovery and treatment; although construction activities would be expected to be completed in a finite timeframe (months to possibly several years), the system would need to operate indefinitely. Note that the design/construction timeframe for Alternative 8 could be especially protracted due to the need to obtain indefinite access to at least 12 private properties, (assuming the necessary accesses could be acquired at all). Also note that the potential for risks to workers was considered greater for Alternatives 4, 4C, 7 and 8 due to potential exposure to high concentrations of contaminants (DNAPL) during the construction of the source area extraction well and treatment system. A similar concern existed for Alternative 6 due to potential worker exposure to a strong oxidizing agent.

One significant observation relative to *implementability* is that Alternatives 1 and 2 have essentially already been successfully implemented (it is noted that Alternative 2 would require execution of a deed restriction on the 120 Mill Street property, but this is considered a relatively simple administrative procedure). Additionally, implementation of Alternative 3 is considered very easy to successfully implement because the OU1 system has been determined to have sufficient capacity to accommodate the increased pumping, with the possible exception of some minor modifications to the existing OU1 recovery and treatment system.

Alternative 4 is also considered to be a good alternative in terms of its implementability. Although it would require installation or construction of a source area recovery well, candidate wells already exist at the 120 Mill Street property. Additionally, the effluent from the recovery well could be discharged to the local POTW. In contrast, Alternatives 4C, 7 and 8 are considered progressively more difficult to implement. Each would require that the treated effluent be discharged either to a local surface water or to the municipal storm sewer (a direct discharge) ~~the construction of an approximate one mile effluent pipeline to convey the effluent from the source area recovery and treatment system to Morris Run~~ because the volume of ground water extracted exceeds the capacity of the POTW. Alternatives 7 and 8 would also require acquisition of indefinite private property access for the installation and construction of the downgradient recovery wells and the collection/conveyance system.

RESPONSE ACTION:					
Technology Type	**Description**	**Effectiveness**	**Implementability**	**Relative Cost**	**Screening Result**
CONTAINMENT:					
Low-Permeability Cap	A low-permeability cap consisting of soil, clay, asphalt, concrete, and/or geosynthetic materials constructed over impacted areas or source areas to prevent water infiltration and constituent leaching.	• Effective to prevent direct contact with contaminated media, and reduce surface water infiltration through contaminated materials and subsequent migration to ground water. • Effective for large waste volumes. • Ineffective for DNAPL sources.	• Easily implemented. • Materials and equipment are readily available. • Consistent with anticipated future land use.	• Capital: Low to Moderate • O&M: Low	Eliminated from further consideration because findings of the remedial investigation and baseline risk assessment indicated on-site soils are not a source of ground water contamination and do not pose an unacceptable risk to human health or the environment. RI also indicated likely presence of DNAPL.
Vertical Barriers/ Grouting (e.g., slurry walls, sheet pile walls, grout curtains, etc.)	A low-permeability wall or barrier constructed around impacted materials to redirect uncontaminated ground water away from contaminated areas and/or to contain impacted ground water within contaminated areas.	• Effective to reduce contaminant mobilization and migration in ground water. • Requires suitable site and geologic conditions to be effective.	• Materials and equipment are readily available. • Difficult to construct a reliable barrier in fractured bedrock. • Not feasible to construct at depths of known ground water contamination in a fractured bedrock aquifer (i.e., 100-500 feet below ground surface).	• Capital: High • O&M: Low	Eliminated from further consideration due to technical infeasibility of implementation in a fractured bedrock aquifer and high costs.
Hydraulic Barriers (~~i.e.,~~ extraction ~~or injection~~ wells)	A hydraulic barrier to prevent contaminant migration is created using ~~either~~ extraction ~~or injection~~ wells.	• Effective to prevent plume migration. ~~• Injection wells require suitable geologic and hydrogeologic conditions to be effective.~~	• Extraction wells would require treatment and disposal or reinjection of extracted water. • Extraction wells will require treatment and disposal ~~or reinjection~~ of extracted water.	• Capital: Low to moderate • O&M: Moderate	~~Eliminated from~~ Retained for further consideration. ~~due to high maintenance requirements and costs relative to other potential technologies.~~
Hydraulic Barriers (~~i.e., extraction or~~ injection wells)	A hydraulic barrier to prevent contaminant migration is created using ~~either extraction or~~ injection wells.	• Effective to prevent plume migration. • Injection wells require suitable geologic and hydrogeologic conditions to be effective.	• Injection wells typically require high maintenance due to well blockage from fine sediment and/or bacteria, effects of air entrainment and water chemistry reactions. • The receiving aquifer must have a relatively high permeability.	• Capital: Low to moderate • O&M: Moderate	Eliminated from further consideration due to high maintenance requirements and costs relative to other potential technologies.

RESPONSE ACTION:					
Technology Type	**Description**	**Effectiveness**	**Implementability**	**Relative Cost**	**Screening Result**
DISPOSAL/DISCHARGE OF TREATED GROUND WATER:					
Surface Water Discharge (including the municipal storm sewer system)	Discharge of treated ground water to local surface water body or municipal storm sewer system via one or more point-source locations.	• Effective and reliable method to discharge treated ground water.	• Common method for discharge of treated water. • Requires NPDES permit and treatment and monitoring program to meet permit requirements. • Discharge to municipal storm sewer system contingent upon approval of municipality and adequate hydraulic capacity.	• Capital: Low • O&M: Low	Retained for further consideration for discharge of treated ground water due to effectiveness and cost.
Direct Discharge to Municipal Water Supply System (Water treated to drinking water quality standards)	Discharge of treated ground water directly to existing municipal water supply system after treatment to drinking water standards using an appropriate technology.	• Effective means of discharging treated ground water	• Increases complexity of treatment processes to meet chemical and biological drinking water standards. • Would require additional treatment steps such as disinfection, and record keeping, and testing/reporting requirements.	• Capital: Moderate • O&M: Moderate	Retained for further consideration due to effectiveness and cost of using OU1 treatment system to treat discharge.
Spray Irrigation	Discharge of treated ground water using spray irrigation on public and/or private lands.	• Effective method of discharge if suitable land for irrigation is available in the vicinity of the site. • Would create beneficial use by recharging aquifer in ground water protected area.	• Requires land suitable for irrigation and volume of water to be discharged. • Likely to be problematic during winter months. • Periodic sampling and monitoring will be required.	• Capital: Low to Moderate • O&M: Low	Eliminated from further consideration due to limited areas near site available for year round irrigation and problems associated with spray irrigation during winter months.
Reinject Treated Water into Bedrock Aquifer	Treated ground water is reinjected into aquifer via infiltration galleries or injection wells.	• Provides potentially beneficial method of ground water discharge that would also be a beneficial use by recharging aquifer in ground water protected area. • Could possibly be used to provide hydraulic	• Technically feasible but design and implementation could be difficult, especially in fractured bedrock aquifer. • Substantial O&M effort is likely to maintain efficient operation of infiltration galleries or injection wells. • If performed within the TCE	• Capital: Low to Moderate • O&M: Moderate to high	Eliminated from further consideration due to difficulties of implementing in a fractured bedrock aquifer and high O&M costs.

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Alternative 4C: ~~Reducing the~~ Pumping of OU1 Supply Well @ ~~from~~ 40 gpm ~~to 20 gpm~~, and ~~a~~ Pumping a Source Area Well @ 20 gpm

General Description:	**Ground water recovery by OU1 Supply Well reduced from OU1 requirement of 40 gpm to 20 gpm and a Source Area Well (120 Mill Street) @ 20 gpm with a modified ground water monitoring program and additional institutional controls**
Ground Water Monitoring:	Monitoring of wells specified in the OU1 ROD
Institutional Controls:	Existing Dublin Borough ordinances (#164 and #200) and deed restrictions on land use and ground water use at 120 Mill Street property
Ground Water Recovery:	- OU1 supply well (designated by Dublin Borough as Well 5) @ 20 gpm - Source Area Well @ 20 gpm
Treatment Facility:	- OU1 treatment system - Additional treatment system at 120 Mill Street property
Pretreatment:	- Manganese sequestering
VOC Removal:	- OU1 treatment system air stripper - 120 Mill Street air stripper
Additional treatment:	- Chlorination for disinfection (OU1 effluent) - OU1 and 120 Mill Street - Vapor-phase GAC adsorption of air stripper off-gas - OU1 and 120 Mill Street - Regeneration of spent GAC at an off-site facility
Discharge:	- OU1 - Dublin Borough water distribution system - 120 Mill Street - NPDES permit for direct discharge to surface water - Piping and possible pumping station to convey treated ground water from source area well treatment system to Morris Run for discharge to surface water at a permitted NPDES outfall
System Monitoring:	- OU1 - PADEP requirements for community water systems - 120 Mill Street - influent monitoring - NPDES effluent monitoring of direct discharge to Morris Run

Alternative 5: Pumping OU1 Supply Well and a Downgradient Well

General Description:	**Ground water recovery by OU1 Supply Well @ 40 gpm and a downgradient well @ 24 gpm with a modified ground water monitoring program and additional institutional controls**
Ground Water Monitoring:	Monitoring of wells specified in the OU1 ROD
Institutional Controls:	Existing Dublin Borough ordinances (#164 and #200) and deed restrictions on land use and ground water use at 120 Mill Street property
Ground Water Recovery:	- OU1 supply well (designated by Dublin Borough as Well 5) @ 40 gpm - 1 downgradient well (total depth 450-500 ft) @ 24 gpm with piping to convey ground water to the OU1 treatment system - Obtain permanent easements on private properties or purchase private properties for downgradient wells
Treatment Facility:	- OU1 treatment system
Pretreatment:	Manganese sequestering
VOC Removal:	- OU1 treatment system air stripper
Additional treatment:	- Chlorination for disinfection (OU1 effluent) - OU1 - Vapor-phase GAC adsorption of air stripper off-gas - OU1 - Regeneration of spent GAC at an off-site facility
Discharge:	- OU1 - Dublin Borough water distribution system
System Monitoring:	- OU1 - PADEP requirements for community water systems - Downgradient well location - influent concentrations

Notes: GAC - granular activated carbon
OU1 - Operable Unit 1
NPDES - National Pollutant Discharge Elimination System
PADEP - Pennsylvania Department of Environmental Protection
POTW - Publicly-owned treatment works
ROD - Record of Decision
VOC - Volatile organic compounds

Table 6 Model-Simulated TCE Concentrations Over Time at Various Locations for Additional Ground Water Modeling - Scenario 2
Dublin NPL Site, Dublin, Pennsylvania

Locations	Model Predicted TCE Concentrations (ppb)						Model Predicted Timeframe for Attaining MCL
	0 years	10 years	20 years	30 years	50 years	100 years	
Cell 47, 41							
Layer 1	200	37	5	2	0	0	20 years
Layer 2	500	200	62	49	48	43	Never (always above MCL)
Layer 3	500	245	76	49	42	35	Never (always above MCL)
Layer 4	500	438	243	122	50	26	Never (always above MCL)
Layer 5	500	452	429	352	194	57	Never (always above MCL)
OU1							
Layer 1	0	6	3.7	1.6	0.2	0	16 years (below MCL for years 0-4, then MCL exceeded for years 4-16)
Layer 2	0	6.4	6.1	2.5	0.3	0.05	22 years (below MCL for years 0-7.5, then MCL exceeded for years 7.5-22)
Layer 3	0	7.7	6.6	2.3	0.3	0.05	6 years (below MCL for years 0-6, then MCL exceeded for years 6-22)
Layer 4	0	12.3	9.9	3.3	0.7	0.1	26 years (below MCL for years 0-3, then MCL exceeded for years 3-26)
Layer 5	0	13.3	16.8	8.5	2.4	0.3	37 years (below MCL for years 0-5, then MCL exceeded for years 5-37)
Dublin Acres Wells							
Layer 1 (Well #1)	0	0.9	3.5	4.5	1.5	0.1	Below MCL for years 0-20; approaches MCL after 30 years
Layer 2 (Well #1)	0	0.4	1.1	1.1	1.2	0.57	MCL never exceeded
Layer 1 (Well #2)	0	0.72	3.6	4.85	1.7	0.13	Below MCL for years 0-20; approaches MCL after 30 years
Layer 2 (Well #2)	0	0.5	2.6	3.6	1.6	0.24	MCL never exceeded
Cell 32, 50							
Layer 1	3	0.5	1.4	1.5	0.48	0	MCL never exceeded
Layer 2	3	9	20	11	1.3	0	39 years (below MCL for years 0-7, then MCL exceeded for years 7-39)
Layer 3	0	35	31	12	3	0	40 years (below MCL for years 0-3, then MCL exceeded for years 3-40)
Layer 4	0	50	30	10	2	0	37.5 years (below MCL for years 0-2, then MCL exceeded for years2-37.5)
Layer 5	0	9	27	19	4	0	46.5 years (below MCL for years 0-8.5, then MCL exceeded for years 8.5-46.5)
Downgradient Well							
Layer 1	200	6	0.5	0	0	0	11 years
Layer 2	200	10	1	0.5	0	0	12 years
Layer 3	200	14	2	1	0	0	14.5 years
Layer 4	200	21	5	2	1.5	0	18 years
Fire Dept Well							
Layer 1	3	0.28	0.06	0.02	0.01	0	MCL never exceeded
Layer 2	3	0.45	0.06	0.02	0.01	0	MCL never exceeded

Scenario 2: Source Area Well pumping at 20 gpm
OU 1 pumping at 20 gpm
Three downgradient wells pumping at 5 gpm each

Notes
The concentrations predicted by the model are based on the following assumptions.

The concentrations predicted by the model are based on the following assumptions.
1. Source control well (FTW) operates continually over 100 year period evaluated
2. OU1 supply well operates continually over 100 year period evaluated
3. All downgradient cleanup wells (i.e., 3 wells in Scenario 2 and 12 wells in Scenario 3) operate continually over 100 year period evaluated (although it is noted that it may be possible to shut off certain pumping wells once MCLs are attained)
4. Model does not account for mechanisms that retard contaminant migration, nor contaminant mass confined within bedrock matrix; therefore model overestimates effectiveness in achieving MCLs.

Table C-1

Estimated Costs Summary Table

Remedial Action Alternatives for Operable Unit 2

Dublin NPL Site - Dublin, Pennsylvania

Description	Initial Capital	Annual O&M (Years 1 thru 5)	Annual O&M (Years 6 thru 30)	Net Present Value (30-Year @ 7%)
Alternative 1: No Further Action	$0	$0	$0	$0
Alternative 2: Limited Action	$0	$43,900	$22,000	$362,800
Alternative 3: Increased Pumping of OU-1 Supply Well	$21,600	$50,400	$28,500	$465,100
Alternative 4: Pumping OU-1 Supply Well and a Source Area Well	$87,900	$106,700	$84,800	$1,230,000
Alternative 5: Pumping OU-1 Supply Well and a Downgradient Well	$314,100	$52,300	$30,400	$781,100
Alternative 6: Pumping OU-1 Supply Well and Source Area In-situ Treatment	$264,800	$43,900	$22,000	$627,600
Alternative 4C: Pumping OU-1 Supply Well and a Source Area Well (@ 20 gpm)	$105,200	$88,700	$66,800	$1,023,900
Alternative 7: Pumping Source Area Well (@ 20 gpm) and 3 DGWs (@ 5 gpm)	$636,500	$99,100	$77,200	≥ $1,684,300*
Alternative 8: Pumping Source Area Well (@ 20 gpm) and 12 DGWs (@ 5 gpm)	$2,807,200	$118,800	$96,900	≥ $4,099,400*

~~* These costs likely reflect lower end of a cost range; due to numerous implementability issues, the upper end of the cost range would be the conclusion that the alternative is not implementable at any cost.~~

* *In comparison to the other alternatives evaluated, the complexity of design associated with this alternative causes the estimated cost to be less accurate than the estimates for other alternatives and, in all likelihood, reflects the lower end of a cost range.*

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Table C-5
Alternative 5: Pumping OU-1 Supply Well and a Downgradient Well
Estimated Costs Summary
Remedial Action for Operable Unit 2
Dublin NPL Site - Dublin, Pennsylvania

Cost Item	Quantity/ Unit		Unit Cost	Total Cost
Capital Costs				
Well Pump	1	each	$3,000	$3,000
Pipe Installation to OU-1 System	1,600	linear feet	$8	$12,800
Road Crossing and Restoration	1	lump sum	$3,500	$3,500
Blower	3	each	$1,200	$3,600
Booster Pump	1	each	$3,500	$3,500
Piping and Connections	1	lump sum	$1,500	$1,500
Control Modifications	1	lump sum	$1,000	$1,000
Property Access (DGW/pipeline)	3	acre	$55,000	$165,000
			Subtotal:	$193,900
			Contingency (20%):	$38,800
			Subtotal:	$232,700
			Administration & Permits (5%):	$11,600
			Legal (5%):	$11,600
			Engineering (25%):	$58,200
			Total:	**$314,100**
Annual O&M Costs				
Chemical Usage				
Sequestering Solution	75	gallon	$20	$1,500
Disinfecting Solution	340	gallon	$2	$700
VPGAC Change-out w/Disposal	600	pound	$3	$1,800
Equipment Replacement	1	lump sum	$1,000	$1,000
Electrical Costs	19,600	kilowatt-hour	$0.10	$2,000
			Subtotal:	$7,000
			Contingency (20%):	$1,400
			Total Annual O&M Costs:	**$8,400**
Ground Water Monitoring Costs (per event)				
Labor (2-person crew)	7	day	$1,200	$8,400
Equipment Rental, Expenses	1	lump sum	$3,860	$3,900
Laboratory Analysis	20	each	$250	$5,000
Reporting	1	lump sum	$1,000	$1,000
			Event Total:	$18,300

Table C-5 (continued)
Alternative 5: Pumping OU-1 Supply Well and a Downgradient Well
Estimated Costs Summary
Remedial Action for Operable Unit 2
Dublin NPL Site - Dublin, Pennsylvania

Cost Item	Quantity/ Unit	Unit Cost	Total Cost
Years 1 through 5 (semi-annual frequency)			
Annual Sampling Event	2 each	$18,300	$36,600
		Contingency (20%):	$7,300
	Total Annual Cost (Years 1 through 5):		**$43,900**
Years 6 through 30 (annual frequency)			
Annual Sampling Event	1 each	$18,300	$18,300
		Contingency (20%):	$3,700
	Total Annual Cost (Years 6 through 30):		**$22,000**

SUMMARY OF ESTIMATED COSTS

Capital Costs:	**$314,100**
Annual O&M Costs:	**$8,400**
Annual Ground Water Monitoring Costs (Years 1 through 5):	**$43,900**
Annual Ground Water Monitoring Costs (Years 6 through 30):	**$22,000**
30-Year Net Present Value (@ 7% Discount):	**$781,100**

Assumptions:

1. *Alternative will not involve the installation of new monitoring wells.*
2. *Existing monitoring wells (15) will be sampled semi-annually for the first 5 years and annually thereafter.*
3. *Typical monitoring well: 225 feet deep, 6-inch diameter with a depth-to-ground water of 25 feet.*
4. *Low-flow sampling protocol.*
5. *Monitoring well purge water to be discharged to the sanitary sewer system.*
6. *The conveyance pipeline traverses 3 properties which total 16 acres. It is assumed that access to approximately 3 acres will be necessary to accommodate a reasonable easement (80') for the 1,600 LF of pipeline*

Table C-8
Alternative 7: Pumping Source Area Well (@ 20 gpm) and 3 DGWs (@ 5 gpm)
Estimated Costs Summary
Remedial Action for Operable Unit 2
Dublin NPL Site - Dublin, Pennsylvania

Cost Item	Quantity/ Unit		Unit Cost	Total Cost
Capital Costs				
Site Preparation	1	lump sum	$3,500	$3,500
Piping and Connections	1	lump sum	$8,000	$8,000
Equipment Installation/Setup	1	lump sum	$8,500	$8,500
Pre-packaged Air Stripping System	1	each	$40,000	$40,000
Manganese Sequestering System	1	each	$2,500	$2,500
Well Installation	3	each	$15,000	$45,000
Well Pumps	4	each	$2,500	$10,000
Electric to DGW Well Pumps	3	each	$5,000	$15,000
Piping to Treatment System	3,200	linear foot	$20	$64,000
Vapor Phase GAC System	1	each	$12,000	$12,000
Discharge Piping to Existing Sewer	100	linear foot	$12	$1,200
Manhole at Tie-in Location	1	each	$4,000	$4,000
Property Access	4	acre	$55,000	$220,000
			Subtotal:	$433,700
			Contingency (20%):	$86,700
			Subtotal:	$520,400
			Administration & Permits (5%):	$26,000
			Legal (5%):	$26,000
			Engineering (25%):	$64,100
			Total Capital Costs:	**$636,500**
Annual O&M Costs				
Chemical Usage				
Sequestering Solution	150	gallon	$20	$3,000
Air Stripper Maintenance	1	lump sum	$1,500	$1,500
System Operator Monitoring	120	hour	$60	$7,200
VPGAC Change-out w/Disposal	3,500	pound	$3	$10,500
Equipment Replacement	1	lump sum	$3,500	$3,500
Electrical Costs	65,300	kilowatt-hour	$0.10	$6,500
Stripper Effluent Sampling	12	event	$800	$9,600
NPDES Outfall Sampling	2	event	$1,000	$2,000
			Subtotal:	$43,800
			Contingency (20%):	$8,800
			Subtotal:	$52,600
			Reporting & Administration (5%):	$2,600
			Total Annual O&M Costs:	**$55,200**

Table C-8 (continued)

Alternative 7: Pumping Source Area Well (@ 20 gpm) and 3 DGWs (@ 5 GPM)
Estimated Costs Summary
Remedial Action for Operable Unit 2
Dublin NPL Site - Dublin, Pennsylvania

Cost Item	Quantity/ Unit	Unit Cost	Total Cost
Ground Water Monitoring Costs (per event)			
Labor (2-person crew)	7 day	$1,200	$8,400
Equipment Rental, Expenses	1 lump sum	$3,860	$3,900
Laboratory Analysis	20 each	$250	$5,000
Reporting	1 lump sum	$1,000	$1,000
		Event Total:	$18,300
Years 1 through 5 (semi-annual frequency)			
Annual Sampling Event	2 each	$18,300	$36,600
		Contingency (20%):	$7,300
		Total Annual Cost (Years 1 through 5):	**$43,900**
Years 6 through 30 (annual frequency)			
Annual Sampling Event	1 each	$18,300	$18,300
		Contingency (20%):	$3,700
		Total Annual Cost (Years 6 through 30):	**$22,000**

SUMMARY OF ESTIMATED COSTS

Capital Costs:	**$636,500**
Annual O&M Costs:	**$55,200**
Annual Ground Water Monitoring Costs (Years 1 through 5):	**$43,900**
Annual Ground Water Monitoring Costs (Years 6 through 30):	**$22,000**
30-Year Net Present Value (@ 7% Discount):	**≥ $1,684,300***

Assumptions:

1. *Alternative will not involve the installation of new monitoring wells.*
2. *Existing monitoring wells (15) will be sampled semi-annually for the first 5 years and annually thereafter.*
3. *Typical monitoring well: 225 feet deep, 6-inch diameter with a depth-to-ground water of 25 feet.*
4. *Low-flow sampling protocol.*
5. *Monitoring well purge water to be discharged to the sanitary sewer system.*
6. *Downgradient well installation will require the purchase of both residential and commercial properties at fair market value.*
7. *Cost assumed for property access is half the full property purchase value, which represents the median of the likely cost range.* *Fair market value of residential and commercial properties reported ~~assumed~~ to be $80,000 and $140,000 per acre on average, respectively.* *Acreage assumed to be required is based on a conceptual pipeline routing design intended to minimize total length of pipeline and number of property accesses required. (Note - similar estimate of acreage derived by assuming a reasonable easement (80') for the total length of the pipeline.)*
8. *Typical downgradient well: 450 feet deep, 30 feet of casing and 6-inch open bore.*
9. *Existing~~,~~ onsite storm sewer has the capacity to manage anticipated additional flow.*

~~* These costs likely reflect lower end of a cost range; due to numerous implementability issues, the upper end of the cost range would be the conclusion that the alternative is not implementable at any cost.~~

** In comparison to other alternatives evaluated, the complexity of design associated with this alternative causes the estimated cost to be less accurate than the estimates for other alternatives and, in all likelihood, reflects the lower end of a cost range.*

Table C-9
Alternative 8: Pumping Source Area Well (@ 20 gpm) and 12 DGWs (@ 5 gpm)
Estimated Costs Summary
Remedial Action for Operable Unit 2
Dublin NPL Site - Dublin, Pennsylvania

Cost Item	Quantity/ Unit		Unit Cost	Total Cost
Capital Costs				
Site Preparation	1	lump sum	$3,500	$3,500
Piping and Connections	1	lump sum	$8,000	$8,000
Equipment Installation/Setup	1	lump sum	$9,500	$9,500
Pre-packaged Air Stripping System	1	each	$60,000	$60,000
Manganese Sequestering System	1	each	$3,000	$3,000
Well Installation	12	each	$15,000	$180,000
Well Pumps	13	each	$2,500	$32,500
Electric to DGW Well Pumps	12	each	$5,000	$60,000
Piping to Treatment System	12,000	linear foot	$22	$264,000
Vapor Phase GAC System	1	each	$12,000	$12,000
Discharge Piping to Existing Sewer	100	linear foot	$14	$1,400
Manhole at Tie-in Location	1	each	$4,000	$4,000
Property Access	25	acre	$53,750	$1,343,800
			Subtotal:	$1,981,700
			Contingency (20%):	$396,300
			Subtotal:	$2,378,000
			Administration & Permits (5%):	$118,900
			Legal (5%):	$118,900
			Engineering (25%):	$191,400
			Total Capital Costs:	**$2,807,200**
Annual O&M Costs				
Chemical Usage				
Sequestering Solution	350	gallon	$20	$7,000
Air Stripper Maintenance	1	lump sum	$1,500	$1,500
System Operator Monitoring	120	hour	$60	$7,200
VPGAC Change-out w/Disposal	5,000	pound	$3	$15,000
Equipment Replacement	1	lump sum	$4,000	$4,000
Electrical Costs	130,600	kilowatt-hour	$0.10	$13,100
Stripper Effluent Sampling	12	event	$800	$9,600
NPDES Outfall Sampling	2	event	$1,000	$2,000
			Subtotal:	$59,400
			Contingency (20%):	$11,900
			Subtotal:	$71,300
			Reporting & Administration (5%):	$3,600
			Total Annual O&M Costs:	**$74,900**

Table C-9 (continued)
Alternative 8: Pumping Source Area Well (@ 20 gpm) and 12 DGWs (@ 5 GPM)
Estimated Costs Summary
Remedial Action for Operable Unit 2
Dublin NPL Site - Dublin, Pennsylvania

Cost Item	Quantity/ Unit	Unit Cost	Total Cost
Ground Water Mon... ring Costs (per event)			
Labor (2-person crew)	7 day	$1,200	$8,400
Equipment Rental, Expenses	1 lump sum	$3,860	$3,900
Laboratory Analysis	20 each	$250	$5,000
Reporting	1 lump sum	$1,000	$1,000
		Event Total:	$18,300
Years 1 through 5 (semi-annual frequency)			
Annual Sampling Event	2 each	$18,300	$36,600
		Contingency (20%):	$7,300
		Total Annual Cost (Years 1 through 5):	**$43,900**
Years 6 through 30 (annual frequency)			
Annual Sampling Event	1 each	$18,300	$18,300
		Contingency (20%):	$3,700
		Total Annual Cost (Years 6 through 30):	**$22,000**

SUMMARY OF ESTIMATED COSTS

Capital Costs:	**$2,807,200**
Annual O&M Costs:	**$74,900**
Annual Ground Water Monitoring Costs (Years 1 through 5):	**$43,900**
Annual Ground Water Monitoring Costs (Years 6 through 30):	**$22,000**
30-Year Net Present Value (@ 7% Discount):	**≥ $4,099,400***

Assumptions:

1. *Alternative will not involve the installation of new monitoring wells.*
2. *Existing monitoring wells (15) will be sampled semi-annually for the first 5 years and annually thereafter.*
3. *Typical monitoring well: 225 feet deep, 6-inch diameter with a depth-to-ground water of 25 feet.*
4. *Low-flow sampling protocol.*
5. *Monitoring well purge water to be discharged to the sanitary sewer system.*
6. *Downgradient well installation will require the purchase of both residential and commercial properties at fair market value.*
7. *Cost assumed for property access is half the full property purchase value, which represents the median of the likely cost range. Fair market value of residential and commercial properties reported ~~assumed~~ to be $80,000 and $140,000 per acre on average, respectively. Acreage assumed to be required is based on a conceptual pipeline routing design intended to minimize total length of pipeline and number of property accesses required. (Note - similar estimate of acreage derived by assuming a reasonable (80') casement for the total length of pipeline.)*
8. *Typical downgradient well: 450 feet deep, 30 feet of casing and 6-inch open bore.*
9. *Existing~~,~~ onsite storm sewer has the capacity to manage anticipated additional flow.*

~~* These costs likely reflect lower end of a cost range; due to numerous implementability issues, the upper end of the cost range would be the conclusion that the alternative is not implementable at any cost.~~

** In comparison to other alternatives evaluated, the complexity of design associated with this alternative causes the estimated cost to be less accurate than the estimates for other alternatives and, in all likelihood, reflects the lower end of a cost range.*

Table 7 Comparative Analysis of Alternatives

Criteria	Alternative No. 1 No Further Action	Alternative No. 2 Limited Action	Alternative No. 3 Increased Pumping of OU1 Supply Well	Alternative No. 4 OU1 (@40 gpm) and a Source Area Well @ 5 gpm	Alternative 4C OU1 (@40 gpm) and a Source Area Well @ 20 gpm
1. *Overall Protection of Human Health and the Environment*	*Acceptable* - No unacceptable risks under current conditions; institutional controls and routine monitoring provide protection in the future.	*Good* - No unacceptable risks under current conditions; institutional controls and routine monitoring provide protection in the future; additional institutional controls (deed restriction) provide greater level of protection in the future and revised monitoring program provides more useful information for characterizing plume extent, remedy performance and potential risks to human health.	*Very Good* - Same as Alt #2 with greater protection to municipal and community supply wells (i.e., reduced contaminant concentrations predicted at OU1, Dublin Borough Well #3, and Dublin Acres wells).	*Very Good* - Same as Alt #2 with greater protection to municipal and community supply wells (i.e., reduced contaminant concentrations predicted at OU1, Dublin Borough Well #3, and Dublin Acres wells).	*Very Good* – Same as Alt #4, but even lower concentrations predicted at OU1, Dublin Borough Well #3, and Dublin Acres wells as a result of complete hydraulic containment of source material.
2. *Compliance with ARARs/TBCs*	*Acceptable* - Fully compliant. Remote potential for non-compliance with SDWA at Borough Wells #3 and 5, and Dublin Acres community well.	*Acceptable* - Fully compliant. Remote potential for non-compliance with SDWA at Borough Wells #3 and 5, and Dublin Acres community well.	*Acceptable* - Fully compliant.	*Acceptable* - Fully compliant	*Acceptable* – Expected to be fully compliant, but increased potential for CWA violations due to direct discharge to ~~Morris Run~~ municipal storm sewer.
3. *Long-Term Effectiveness and Permanence* - *Magnitude of residual risk* - *Adequacy/reliability of controls*	*Acceptable* - Fully protective (in conjunction with institutional controls and monitoring) but does not achieve RAOs of source control and aquifer restoration.	*Acceptable/Good* – Same as Alt. #1 ~~Fully protective~~ (with greater long-term assurances than Alt. #1) but does not achieve RAOs of source control and aquifer restoration.	*Good* - Better protection for Dublin Acres and Borough Well #3, and reduces potential need for upgrades to OU1 treatment system. Does not achieve RAOs of source control and aquifer restoration.	*Good/Very Good* - Better protection for Dublin Acres and Borough Well #3, and reduces potential need for upgrades to OU1 treatment system. Achieves RAO of source control but does not restore aquifer.	*Very Good* – Enhanced source control (i.e., complete hydraulic containment) in comparison to Alt #4; consequently greater degree of aquifer restoration than Alt #s 1-6 However, restoration neither complete nor permanent.
4. *Reduction of Toxicity, Mobility or Volume*	*Poor* - Only reduction in toxicity or volume is achieved via pumping of OU1 supply well and natural attenuative processes; mobility not a significant issue due to plume stability indicated by RI	*Poor*- Only reduction in toxicity or volume is achieved via pumping of OU1 supply well and natural attenuative processes, mobility not a significant issue due to plume stability indicated by RI	*Poor* Only reduction in toxicity or volume is achieved via pumping of OU1 (enhanced in comparison to Alt. #s 1 & 2) and natural attenuative processes; mobility not a significant issue due to plume stability indicated by RI	*Good* - Reduces mobility and volume (mass but not extent) of contamination through source control, however, DNAPL source and dissolved phase contamination (>MCLs) would persist for extended period of time	*Very Good* Complete hydraulic containment of source material significantly reduces contaminant migration.

Continued on Page 2

Continued on Page 3

Table 7 Comparative Analysis of Alternatives (continued)

Criteria	Alternative No. 5 OU1 and a Downgradient Well	Alternative No. 6 OU1 and Source Area In-Situ Treatment	Alternative No. 7 OU1 (@ 20 gpm), Source Area Well @ 20 gpm, and 3 Downgradient Recovery Wells	Alternative No. 8 OU1 (@ 20 gpm), Source Area Well @ 20 gpm, and 12 Downgradient Recovery Wells
1 *Overall Protection of Human Health and the Environment*	*Acceptable* - No unacceptable risks under current conditions; institutional controls and routine monitoring provide protection in the future. Increases potential for exposure to contaminated ground water due to lateral spread of plume induced by downgradient pumping well.	*Acceptable - Same as Alt. #2* Provides no greater level of protection than other alternatives over long-term, and results in increased short term risks to site workers during implementation.	*Acceptable* – No unacceptable risks under current conditions; however concentrations approaching MCLs are predicted to reach Dublin Acres supply wells and Borough Well #3 approximately 30 years in future. Additional risk introduced by need to collect and convey contaminated ground water through portions of Borough.	*Acceptable/Good* – No unacceptable risks under current conditions and provides the most comprehensive and accelerated restoration of the aquifer; therefore, least amount of residual risk. However, additional risk introduced by need to collect and convey contaminated ground water through portions of Borough.
2 *Compliance with ARARs/TBCs*	*Acceptable* - Fully compliant.	*Acceptable* - Fully compliant.	*Acceptable/~~Poor~~* – Increased potential for CWA violations due to direct discharge to ~~Morris Run~~ municipal storm sewer and collection and conveyance of contaminated water through ~3,200 feet of pipeline.	*Acceptable ~~/Poor~~* – Increased potential for CWA violations due to direct discharge to ~~Morris Run~~ municipal storm sewer and collection and conveyance of contaminated water through ~5,300 feet of pipeline.
3. *Long-Term Effectiveness and Permanence* - *Magnitude of residual risk* - *Adequacy/reliability of controls*	*Good* - Fully protective (in conjunction with institutional controls and monitoring), but magnitude of residual risk increased due to lateral spread of plume. Does not achieve RAOs for source control and aquifer restoration.	*Good* - Fully protective and achieves reduction in magnitude of residual risk through significant reduction in contaminant source. Does not restore aquifer and does not fully achieve source control (in contrast to Alt. #4).	*Acceptable/Good* – Same as Alt # 4C but increased potential for MCL exceedances at Dublin Acres supply wells and Borough Well #3 approximately 30 years in future. Complete source control and high degree of aquifer restoration; however restoration not complete nor permanent.	*Very Good/Excellent* - Complete source control and highest degree of aquifer restoration; however, restoration not complete nor permanent.
4. *Reduction of Toxicity, Mobility, or Volume*	*Acceptable/Poor* - Increases lateral spread of plume and therefore increases volume of aquifer that is impacted.	*Good* - Reduces mobility and volume (mass but not extent) of contamination through source control; however, DNAPL source and dissolved phase contamination (>MCLs) would persist for extended period of time.	*Acceptable/Good* – Complete hydraulic containment of source material significantly reduces high strength contaminant migration. However, reduced pumping of OU1 well results in increased migration of lower levels of contamination beyond OU1 well.	*Very Good/Excellent* – Greatest reduction in migration of contamination and mass removal.

Continued on Page 4

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Table 7 Comparative Analysis of Alternatives (continued)

Criteria	Alternative No. 1 No Further Action	Alternative No. 2 Limited Action	Alternative No. 3 Increased Pumping of OU1 Supply Well	Alternative No. 4 OU1 and a Source Area Well @ 5 gpm	Alternative 4C OU1 and a Source Area Well @ 20 gpm
5. *Short-Term Effectiveness* - *Time until action complete* - *Protection of community during implementation* - *Protection of workers during implementation*	*Very Good* - All remedial actions completed; no short-term risks.	*Very Good* - All remedial actions completed; no short-term risks.	*Very Good* - No additional risks; implementation/O&M period essentially the same as Alts. #1 and #2.	*Acceptable* - Higher risks to site workers during construction and O&M due to potential exposure to TCE as NAPL, extended implementation and O&M periods.	*Acceptable/~~Poor~~* - Higher risks to site workers during construction and O&M due to potential exposure to TCE as NAPL. ~~Also potential for short-term risks to human health and ecological receptors from breaches in effluent pipeline and/or treatment system upsets.~~ Although unlikely, any breaches in integrity of ground water collection, conveyance and treatment system could result in exposures to elevated contaminant concentrations.
6. *Implementability* - *Ability to construct and operate* - *Ease of doing more if needed* - *Ability to monitor effectiveness* - *Ability to obtain approvals and coordinate with other agencies* - *Availability of materials, services, and equipment* - *Availability of technologies*	*Very Good* - Implementation already successfully completed.	*Good* - Majority of implementation already successfully completed; additional measures easily implemented.	*Very Good* - Advantageous for Borough because only one supply well needed to meet total demand, therefore Borough's O&M costs reduced and other existing supply wells became available as backup wells.	*Good* - Would likely require pretreatment and acquisition of pretreatment permit for discharge; property access not an issue	*Acceptable* - Extensive treatment system required to treat source area contamination sufficient for direct discharge. Effluent pipeline/outfall would require acquisition of property access and approvals from other agencies, including DRBC for ground water withdrawals >10,000 gpd and Hilltown Township for routing
7. *Cost*					
- *Capital*	$0	$0	$21,600	$87,900	$~~205,100~~105,200
- *Annual O&M**	$0	$43,900/$22,000	$50,400/$28,500	$106,700/$84,800	$88,700/66,800
- *Total present worth*	$0	$362,800	$465,100	$1,230,000	$~~1,123,800~~1,023,900
8. *State Acceptance***	...	...	...		...
9. *Community Acceptance***	...	...	...	...	...

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AR302617

Table 7 Comparative Analysis of Alternatives (continued)

Criteria	Alternative No. 5 OU1 and a Downgradient Well	Alternative No. 6 OU1 and Source Area In-Situ Treatment	Alternative No. 7 OU1 (@ 20 gpm), Source Area Well @ 20 gpm, and 3 Downgradient Recovery Wells	Alternative No. 8 OU1 (@ 20 gpm), Source Area Well @ 20 gpm, and 12 Downgradient Recovery Wells
5. *Short-Term Effectiveness* - *Time until action complete* - *Protection of community during implementation* - *Protection of workers during implementation*	*Acceptable* - Limited, if any, short-term risks; extended implementation/O&M period.	*Acceptable* - Higher risks to site workers during implementation due to potential chemical exposures; implementation timeframe <1 yr.	*Acceptable* ~~/Poor~~ Higher risks to site workers during construction and O&M due to potential exposure to TCE as NAPL. ~~Also, potential for short-term risks to human health and ecological receptors from breaches in effluent pipeline and/or treatment system upsets.~~ Although unlikely, any breaches in integrity of ground water collection, conveyance and treatment system could result in exposures to elevated contaminant concentrations.	*Acceptable*~~/Poor~~ - Same as Alt # 7 but even longer implementation timeframe due to number of property accesses required.
6. *Implementability* - *Ability to construct and operate* - *Ease of doing more if needed* - *Ability to monitor effectiveness* - *Ability to obtain approvals and coordinate with other agencies.* - *Availability of materials, services, and equipment* - *Availability of technologies*	*Acceptable* - Locating a well with suitable yield could be difficult, as could obtaining property access for well and conveyance pipeline. DRBC approval required for ground water withdrawals >10,000 gpd.	*Acceptable/Poor (potentially)* - Effectiveness of technology in deep fractured bedrock aquifer not well established. Requires more materials than other alternatives.	*Poor*~~/Questionable~~ - Same as Alt # 4C except for the need to obtain indefinite property access for 3 recovery wells and collection/conveyance system. DRBC approval could be more of an issue due to increased ground water withdrawal in comparison to Alt #4C.	~~*Unlikely*~~ *Poor* - Same as Alt # 7 except for the need to obtain indefinite property access for 12 recovery wells and at least 5,300 ft of collection/conveyance system. DRBC could have more concerns ~~approval could be more of an issue~~ (in comparison to Alts #4C and 7) due to total withdrawal and volume of water unavailable for public use ~~non-beneficial use of >10x allowable limit~~.
7. *Cost*				
- *Capital*	~~$71,000~~ 314,000	$264,800	~~$1,027,900~~ $636,500	~~$4,699,200~~ $2,807,200
- *Annual O&M**	$52,300/$30,400	$43,900/$22,000	$99,100/77,200	$118,800/96,900
- *Total present worth*	~~$538,100~~ 781,100	$627,600	~~$2,075,700 NF***~~ > $1,684,300***	~~$5,991,400 NF***~~ > $4,099,400 ***
8. *State Acceptance***	---	---	---	---
9. *Community Acceptance***	---	---	---	---

Notes:
* Annual O&M costs reflect distinction between costs for first five years and years 6 through 30
** To be evaluated subsequent to this FS
~~*** NF = Not Feasible, estimated costs likely reflect lower end of a cost range – due to numerous implementability issues, the upper end of the cost range would be the conclusion that the alternative is not implementable at any cost~~
**** In comparison to the other alternatives evaluated, the complexity of design associated with this alternative causes the estimated cost to be less accurate than the estimates for other alternatives and, in all likelihood, reflects the lower end of a cost range